ANGLIA RUSKIN UNIVERSITY

NIGERIA’S ENERGY TRANSITIONS:

POLICY DECISIONS, INFLUENCES AND UNINTENDED CONSEQUENCES

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ABSTRACT

FACULTY OF SCIENCE AND TECHNOLOGY

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It is argued that policy makers have very important roles in governing transitions in any given society through established institutional frameworks. It has also been argued that energy infrastructure choices are determined by institutional dynamics and structures. However, what are the influences underlying changes in energy supply infrastructure? Not many studies have been done on these underlying influences, particularly in a developing country context. This thesis focuses on highlighting the role of the policy making processes and their influences on energy infrastructure provisions and energy systems change.

Informed by critical realism as the chosen research philosophy, the use of mixed methods was adopted in conducting the study with a specific focus on the Nigerian case. Documentary data were gathered from policy documents and archives of various institutions. Qualitative data were gathered, using semi-structured interviews, from people who have been involved in the policy making process and those who have been involved in planning, specification and maintenance of new and existing energy infrastructure.

The study reveals: that there is a complex relationship between resources, institutions, and political structures in the governance of energy infrastructure; that energy transitions were influenced by government policies implemented within and through institutions; and that there is increased need for partnership and interaction between public and private institutions in the governance and provision of energy infrastructure.

The study concludes by highlighting that: (1) energy infrastructure provision is primarily a political choice. (2) Technological changes in electricity supply systems are a major catalyst in shaping the kind of energy infrastructure we end up with. (3) Energy resource availability and reserves plays a major role in the technology choices for electricity infrastructure provision and use. (4) The 'geographies of energy' is a major factor that influences energy production and consumption dynamics.

Keywords: Energy policy; Energy histories; Nigeria; Developing countries; Africa.

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Part I: Introduction, scene-setting and research context.

Chapter 1 INTRODUCTION

Energy transitions entail a shift, or movement, in the use of fossil fuel in our energy supply systems (O'Connor 2010). Across the world, fossil fuels, such as coal, crude oil and natural gas, accounts for a large percentage of our energy supplies. Why then are we interested in energy transitions? Beyond the fact that most fossil fuel resources are reserve based, which means they are limited, the major driver of energy transitions is the threat posed by burning the available large quantities of fossil fuels and their corresponding impact on the environment (Cherp et al. 2011). How do we generate this transition? The clean energy transition is somewhat unique because it has to be driven by policy. Markets cannot provide the platform to reduce greenhouse gas emissions, since markets tend towards the least cost option which at the moment is fossil fuel. As such, it is important to understand the role of policy, policy levers and policy decisions, in effecting energy transitions within the political economy (Baker 2016).

The overall title of this thesis, 'Nigeria's energy transitions: policy decisions, influences and unintended consequences', attempts to immediately convey that the changes in energy systems and use in Nigeria, over time, were influenced by the policy decision processes, which yielded intended and unintended consequences.

Understanding how policy decisions are taken, how current policies are interpreted, and how energy infrastructure is shaped, is dependent on the understanding of the actors and stakeholders, their socio-psychological biases, the internal workings of the institutions within which they act, and their organization's wider interests. On this basis, the broader influences and consequences of the policy decision process and energy governance need to be considered. Indeed, it is on this basis that the central research question, which is the focus of this thesis, is focussed on:

What are the policy making influences on electricity supply infrastructure?

Investigating the past, and understanding the factors that influenced the patterns of energy use can be very useful to policy makers and other energy stakeholders in effectively governing the affairs of the energy sector, and ensuring that the right energy infrastructure is provided that satisfactorily addresses the energy need of people in society. This research questions the Nigerian energy governance structure within the electricity sub-sector by investigating the linkages between policy making and electricity infrastructure provision. These linkages are investigated by exploring three sub-aims/questions which aids in answering the central research question:

Sub-aim 1 - How has electricity supply infrastructure evolved over time and what contexts have influenced this evolution?

Addressed in chapter 4

Sub-aim 2 - What exactly constitutes the practice of policy making, and how has this influenced electricity supply infrastructure provision and energy policy?

Addressed in chapter 5

Sub-aim 3 - What are the linkages and consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision?

Addressed in chapter 6

Table 1.1 shows a breakdown and summary of each chapter's purpose. It shows the approach of the thesis, clarifies the structure, and thus, the journey taken in carrying out this study.

Table 1.1: thesis chapter breakdown

No	Chapter title	Purpose
Part I – Introduction, scene-setting, and research context		
1	Introduction	Introduces and clarifies the overall direction of the thesis, and explains how the thesis is structured.
2	Influences on electricity supply infrastructure? A comparison of different theoretical perspectives.	This chapter contextualizes the thesis within the relevant theoretical framework which leads on to identifying the gaps in knowledge and deriving the research question(s) which the thesis answers.
Part II – Research design.		
3	Research methodology	This chapter outlines the philosophies of science and the rationale behind my choice of critical realism as my chosen research philosophy. It presents the chosen methodological approach and my reasons for choosing case study design. It broadly describes the methods utilized in this thesis, and the necessary steps taken to adhere to the principles of ethical research.
Part III – Results and analysis.		
4	Energy transitions in Nigeria: the evolution of energy infrastructure provisions (1800 – 2015).	Addresses sub-aim 1
5	Policy making and energy infrastructure change: a Nigerian case study of energy governance in the electricity sector.	Addresses sub-aim 2
6	The role of policy makers and institutions in the energy sector: the case of electricity infrastructure governance in Nigeria.	Addresses sub-aim 3
Part IV – Discussion		
7	Discussion	Pulling from the findings of chapters 4 – 6, this chapter discusses the salient issues and influences identified in the research.
Part V – Conclusion		
8	Conclusions	This chapter presents the key conclusions of this thesis. It also highlights the contribution of this thesis to the existing body of knowledge and some considerations for future research.

Table 1.1 reveals how the next chapter (in chapter 2) delves into the theoretical context that underlies the central research question of this thesis. It discusses how the research question can be answered through investigating the three sub-aims. The design and methodological approach of this thesis is then presented (in chapter 3), within which the advantages and disadvantages of the various methods and methodologies are discussed. This discussion provides a foundation to, and complements, the methods in the results, analysis and discussions section covered in chapters 4 - 7, which addresses the specific sub-aims that form the core of this thesis. Similarly, each of the results chapters provides justification on how addressing each sub-aim of this thesis helps in filling a knowledge gap in itself, as well as in the context of the central research question that underpins this thesis.

The literature review chapter, as well as the three results and analysis chapters, are based significantly on the following papers, which have been published.

1. Edomah N., Foulds C., and Jones A.. (2017), "Influences on energy supply infrastructure? A comparison of different theoretical perspectives*" Renewable and Sustainable Energy Reviews*, 79. Pg. 765-778.
2. Edomah. N. (2015). "An analysis of the techno-economic dynamics of energy infrastructure investment"*. International Energy Journal*. Regional Energy Resources Information Centre (RERIC), Asian Institute of Technology. 15(2). Pg. 83-92. ISSN 1513-718X

   These form the basis for chapter 2.

3. Edomah, N., Foulds, C. & Jones, A., (2016). Energy Transitions in Nigeria : The Evolution of Energy Infrastructure Provision (1800–2015). *Energies*, 9(7), 484.

   This forms the basis for chapter 4

4. Edomah N., Foulds C., and Jones A. (2017), “Policy making and energy infrastructure change: A Nigerian case study of energy governance in the electricity sector” *Energy Policy*, 102, Pg. 476-485.

   This forms the basis for chapter 5

5. Edomah, N., Foulds, C. & Jones, A., 2016. “The role of policy makers and institutions in the energy sector: The case of energy infrastructure governance in Nigeria”. *Sustainability,* 8(8), 829.

   This forms the basis for chapter 6

6. Edomah, N., 2016. On the path to sustainability: Key issues on Nigeria’s sustainable energy development. *Energy Reports*, 2, Pg. 28–34.
7. Edomah, N. & Nwaubani, S., 2014. Energy security challenges in developing African mega cities: the Lagos experience. *Infrasructure, Risk and Resilience: Managing Complexity and Uncertainty in Developing Cities.* Pg. 3-12.

   These form the basis for chapter 5 and 6.

Chapter 2 INFLUENCES ON ELECTRICITY SUPPLY INFRASTRUCTURE: A COMPARISON OF DIFFERENT THEORETICAL PERSPECTIVES.

This chapter presents the influences on electricity supply infrastructure from five (5) main theoretical perspectives, starting from those that are more individualistic to those that are based on social structures and contexts. I started off by introducing the motive for the review and defining energy supply infrastructure (section 2.1). Afterwards, I delved into the various theoretical perspectives starting with techno-economics (section 2.2), Social psychology (section 2.3), socio-technical transitions (section 2.4), social practices (section 2.5) and institutional theory (section 2.6). Some reflections on the five perspectives are presented in section 2.7 and the corresponding knowledge gaps in section 2.8. A section on ‘energy, corruption and the black economy’ was presented (in section 2.9) due to a general notion that the energy and electricity sector in most developing countries are characterized by corruption (among other factors). This chapter then concludes by presenting the research question(s) (section 2.10) which formed the basis for the rest of the thesis.

2.1. INTRODUCTION

This introductory section presents the background context for the review of the influences on energy supply infrastructure. It also presents a working definition of energy supply infrastructure, as used in this thesis.

2.1.1. Background context.

In recent times, there has been more attention given to building new energy supply infrastructure, either to cater for the growing energy demand, or to continue to supply existing demand by replacing the existing ageing energy supply infrastructure that is reaching the end of its life time.

Adequate supply of energy infrastructural services is essential for economic development (Srinivasu & Islamia 2013). Moreover, such services have been regarded as essential in academic, political, and professional realms as has been observed over the last few decades through considerable efforts to empirical and theoretical evaluation of contributions of energy infrastructure to economic growth and development (Pradhan 2010; Snieska & Simkunaite 2009). Connected to this, attention has also been given to the connection between infrastructure and poverty (UN HABITAT 2011). In as much as current literatures on these topics appear completely distinct; a consensus has undoubtedly been reached (Nicholson & Stepp 2013), under the right conditions, energy infrastructure development can play a major role in economic development through promoting growth.

There have been a series of changes in the energy industry in the past decades, with still more changes expected in the coming years. These changes impact on the energy infrastructures we use (O'Connor & Cleveland 2014). Input to production is regarded as one of the most direct roles of energy today. This means a world without energy and electricity almost amounts to non-mechanized production (UNEP 2006). Inasmuch as erratic electricity supplies disrupt production, voltage fluctuations affects negatively the durability of production equipment as experienced in most developing economies in Africa (Edomah 2009). The efficiency and durability of physical capital is improved by better electricity related infrastructure (Snieska & Simkunaite 2009). Thus, there is a close link between technological progress, capital accumulation, as well as economic growth and development (Akpan & Chuku 2014).

A considerable part of today's prosperity rests on stable and secure access to energy (IFC 2012). In Africa, only one in four has access to electricity (Bazilian et al. 2012). In Latin America, infrastructure is a major determinant of GDP per capita growth, while it is still argued that the continent lags behind in terms of quality and quantity of infrastructure when compared with the international norm (Jaunky 2006).

The United Nations (Sorrell et al. 2011) argues that infrastructure has major implications for a variety of development outcomes at three different levels: (1) the household level, through social mobility, education and health; (2) the firm level, through industrial development and productivity; and (3) the global level, through climate change issues.

<u>2.1.2.</u> What is energy supply infrastructure?

There is currently no universally accepted definition as to what energy supply infrastructure is. However, many authors have provided explanations to various subsets of energy infrastructure, with examples including electricity infrastructure (Volk 2013); petroleum infrastructure (Eleff 2013); natural gas infrastructure (IHS Global Inc 2013); renewable energy infrastructure (World Economic Forum 2009; Belward et al. 2011).

Based upon this fragmented set of literatures, I hereby define energy infrastructure as follows:

> *"Energy supply infrastructure represents the (small and large scale) enablers that help us to extract, produce, transport, and manage energy from producer to consumer"*.

Going forward, the term "energy infrastructure" as used in the subsequent sections of this chapter, refers to all the various aspects of the electricity value chain (from electricity generation to utilization) as already highlighted in the preceding paragraphs. Except where otherwise stated, the term "energy" in this chapter refers to electricity.

In line with this definition, also included are traditional utilities associated with energy management and transport, such as: coal fired trains (Tierney 2012), electricity transmission lines (Martinek & Orlando 2002) and electricity generation plants (OECD 2010). It also includes large scale energy management technologies such as: smart grids (Cherukuri & Nahrstedt 2011; Simmhan & Noor 2013), smart building technologies (Wood & Newborough 2003), modern power plants control systems, and advanced electricity distribution and metering systems (Abdulwahab 2010; Carbon Trust 2005).

The electrical grid in some developed (and developing) countries is based on outdated technologies that are subject to congestion problems (Homeland Security: Science and Technology 2010). The embodied technology in current grid systems in many countries limits the development of renewable sources, including decentralized sources of renewable energy, such as individual home-based solar energy systems (Lo et al. 2012). This is so because it is difficult to distribute surplus energy generated by decentralized sources through the existing electrical energy grid (Graab 2011).

With respect to energy infrastructure, there are several factors, which pose themselves as challenges we have to face, that will play a vital role in ensuring a stable future energy supply (Schock & Sims 2007). These challenges include the following:

1. Hydrocarbon resources will become more difficult to access, and increasingly challenging to produce.
2. Technological requirements will be an increasingly complex and demanding issue, particularly technologies required for greater energy efficiency and energy conservation.
3. Cost of producing and delivering energy will escalate.
4. Demand on current and future infrastructure are growing
5. Human resources may be inadequate to meet projected growth requirements.
6. There are greater and indeterminate environmental constraints

Energy infrastructure provision is connected to other factors, which directly influence the political culture, such as: climate, natural resources (as is common in many countries with fossil fuel reserves), population, and the wider environment (Schultz 2011). Other factors include a nation's historical experiences, language, art, literature, memories, economics, geography and social norms, which also shape the political culture as well as the cultural ethos. The fundamental agreements and trust – without which politics cannot advance as a civilizing process – is provided by the cultural framework that offers sound rules for the political game (Berman et al. 2001).

Investment dynamics also constitute a factor that affects energy. In the last ten years, the investment surge to meet the rising energy demand, mainly in Asia and developing countries, has led to a greater search for better exploration and production technologies (Blumberg 2015). The shale revolution and investment in the United States and the renewables revolution in Europe are concrete examples (PWC 2013; Wang & Krupnick 2013). In Europe, between 2000 and 2010, half of the total investment in electricity infrastructure came from renewable energies. In the United States today, shale gas production is about 250 billion cubic meters. The IEA argues that it is result of the right policies and investment framework, which supports economic investment in new energy infrastructure provisions, rather than pure econometric and cost-benefit calculations (Tinker et al. 2014; IEA 2014b). The IEA further argues that the investment in renewables in Europe is about three times higher than the investment in shale gas production in the Unites States, thus, implying that the increased investments in new energy infrastructure provision is a result of successes and returns on previous investments already made (IEA 2014b).

Investment decisions are becoming more difficult due to the rising levels of uncertainty in forms of changing geopolitical alliances in forming energy deals, geopolitical trends that impact on energy production, fluctuations in energy prices and trade dynamics, issues of poor governance and political instability, threats to infrastructural facilities, and other environmental concerns (Verrastro et al. 2010). Considering possible threats to successful investment in new energy infrastructure, the IEA argues that aside from the rising capital investment cost, other major factors include geo-political concerns which highlights the issue of energy security as the stubborn part of the decision making process (IEA 2014b). Climate change, which constitutes a change in regional and global climate patterns, is also a factor that has to be considered in the choice of energy supply infrastructure (Salas 2013).

2.1.3. Considering theoretical perspectives

As a follow-up to the arguments of the preceding sub-section, I hereby argue that energy supply, in the strict sense of the word, is *not created* but is *caused*. The cause can come in various ways, such as government high-level decisions on new energy infrastructure when there is not high demand for it. The fact that the infrastructure is available now leads to a *shift* to the use of that infrastructure. In this case, the demand is caused by the initial provision of that infrastructure. Another cause can be the consumerist culture of people in society. Attitudinal biases, culture and beliefs, which influences people's social practices (which can be very energy intensive) also contributes to increased energy demand, which then impacts on energy supply infrastructure. Practices influence energy demand levels and patterns, which in turn influences energy supply provision.

Therefore, I argue that changes to energy infrastructure can come about through one or a combination of the following:

1. High-level decision-makers - in particular policy-makers - imposing policies, structures, and instruments that support and aids new energy infrastructure provision.
2. Society consuming energy – through various attitudinal and social practices which impacts on increased energy consumption levels and imposes pressure

on existing energy infrastructure, thus, leading to an increased need for new energy infrastructure. An example of influences on energy infrastructure choices is the perceived safety issues on nuclear power that contributes to people voting against its use for electricity generation, as is the case of Germany (Blackmore 2013). Attitudinal influences impact both the demand side (total volume of infrastructure provided), and the supply side (the actual infrastructure choices).

There is a general consensus that electricity infrastructure supply is influenced by multiple factors (Observatoire Méditerranéen de l'Energie 2007). It is generally believed that the economics of technological options for electricity generation have been dynamic, thus, impacting on the kind of electrical energy supply infrastructure used since some technological options are now becoming cheaper (IEA 2014c; Edomah 2015). There is also a consensus that the activities and practices of people in society over time have been increasingly energy intensive, and that these practices shape social behaviour and impact on increased energy consumption which leads to an increased demand for electricity infrastructure supply (Higginson et al. 2011). The increased quest for psychological benefits which shapes attitudes and habits towards energy consumption is generally believed to have some impact on increased electricity consumption (Whitmarsh 2009; Uzzell 2011). The quest by some interest groups to ensure a shift in electricity access from niche (privileged few) to mainstream (a large majority) is generally perceived to have some influence on the electricity supply infrastructure landscape that can yield multiple social benefits (Chappin 2011). It is also believed that certain institutions involved in energy (oil and gas) and electricity infrastructure decisions and provisions play a vital role in the energy landscape (Van de Graaf 2013; Gao 2016).

In this review, I have decided to investigate those influences that starts from understanding the role of individual agents, to the influences posed within higher social contexts and structures. In doing this, I try to explore the following:

1. How do individual agents, through analysis of costs and benefits, influence energy supply infrastructure provisions? (Techno-economic)
2. How do people's habits and attitudes impact on energy supply infrastructure provisions? (Social psychology)
3. How have practices, over time, impacted on energy supply infrastructure provisions? (Social practices).
4. How have institutional contexts influenced changes in energy supply infrastructure? (Institutional dimensions).
5. How have socio-technical systemic contexts impacted on changes in energy supply infrastructure? (Socio-technical transitions)

Indeed, these questions helped in shaping the choice of the approaches covered in this review. Following the general assumptions of different influences, this review chapter intends to explore these questions from their associated theoretical lenses to see how they impact (directly or indirectly) on electricity infrastructure supply.

There are other perspectives/theoretical lenses that influence energy infrastructure supply, such as: network theory, which studies relationship between discreet variables and actors (Katz et al. 2004); dynamic systems theories, which studies development of complex and non-linear set-ups/arrangements (Thelen & Smith 2006); and complexity theory, which studies interactions and feedback loops that impacts on systems change (Bale et al. 2015). I have not considered these perspectives because they do not really fit well within the context and framework of this research in analysing the various influences on energy supply infrastructure. Indeed, I have chosen these five (5) perspectives (among several options) because they are more appropriate in addressing this research case as the reader will later notice and as demonstrated in this review.

Based on all this context, the purpose of this chapter is to critically review different understandings of the various factors, elements, processes and systems involved in the decision making process relating to the provision of electricity supply infrastructure. Specifically, this review analyses the theoretical reasoning of five perspectives, each of which puts forward its own rationale for explaining how new electricity supply infrastructure has come to be:

1 Techno-economics (section 2.2)
2 Social psychology (section 2.3)
3 Socio-technical transitions (section 2.4)
4 Social practices (section 2.5)
5 Institutional dimensions (section 2.6).

The exploration of the various perspectives starts with those that are linked more to individual cognition (techno-economics and social psychology), before moving to discuss those perspectives that are based more on social context (socio-technical transitions). It also considers two perspectives that situated in the middle ground between these individualistic and social structural perspectives. These two middle ground perspectives are focussed on social practices and institutional dimensions. I then finish this chapter by identifying and stating the knowledge gaps based on the evaluation of the various theoretical perspectives, and the consequent research questions that this research intends to address.

This review now explores how the five different schools of thoughts (perspectives) explain changes in energy infrastructure. It also looks at the interplay of politics within and between the various perspectives. It explores the indirect role of politics on the various perspectives in influencing increased level of electricity demand, which leads to electricity infrastructure deficit that causes the need for more electricity infrastructure supply decisions and the choices of electricity infrastructure provided. This is important as these five perspectives helps to demonstrate electricity infrastructure choices from Individualistic perspectives to those perspectives that are more social context based.

2.2. THE TECHNO-ECONOMICS OF ENERGY INFRASTRUCTURE

This perspective argues that most energy (oil, gas and electricity) infrastructure investment decisions are based on economic processes. It argues that energy investment decisions are more a product of a continuous evaluation of cost and benefits and assumes objective decision-making based on cost-benefit analysis and rational choice.

2.2.1. Overview

The origin of the studies and concept of techno-economic paradigm started with Carlota Perez and C. Freeman (Perez 1985; Freeman & Perez 1988). Perez argues that technology, together with its supporting institutions, constitutes a techno-economic paradigm. This paradigm has been identified as an important element that constitutes the *new technological style* which drives, towards a more intensive use, engineering and investment decisions. Perez further argues that this new technological style induces some sort of best practices/principles which serve as a sort of paradigm for designing the social tools required to grasp the new techno-economic potential, as well as steering institutional change (Pérez 2004).

Considering the aforementioned, it can be argued that the techno-economic paradigm constitute patterns of choices regarding research, development, establishment and furtherance of technologies (Conceição & Heitor 2003). Therefore, a techno-economic paradigm which supports green technologies would induce certain biases in the technological preferences of firms towards environmentally friendly choices. It also influences the choices and preferences of actors in the policy environment, as well as the role of consumers in setting the research and development agenda of firms. Freeman argues that society made choices on innovation with environmental implications between the 1970s and 1980s (Freeman 2002). This resulted to the development of bias favouring environmentally friendly technologies, identified in different facets of policy choices, production and consumption activities as experienced in the beginning of the 1990s.

2.2.2. Politics, political markets and energy investment decisions.

The dynamics and interplay between energy investments decisions, politics, and the political market have some systemic implications for new energy infrastructure provisions. Political markets (Fligstein 1996; White 1993) are comprised of political agents, such as elected officials, as well as officials appointed to run regulatory agencies (Lane 2013) who make decisions that structure exchange among participants in the real market as well as the financial market (Titman 2013). They determine things like taxes, regulations, as well as granting and approving permits as some permitting process may be necessary in energy business (Battocletti & Lawrence 2005; Busche et al. 2013).

The techno-economic paradigm would argue that energy supply infrastructure decisions in the political sphere are influenced by how policy makers and others engage with these market forces, which includes the financial appraisal of each decision’s cost/benefits. Thus, policy makers are considered to be providing energy infrastructure on the basis of rational choice. Some of the influence mechanisms adopted by techno-economists in influencing decisions in the political market (Fatas et al. 2007) include: elections, lobbying, comments contributed during legislative debates and regulatory rulemaking (such as stakeholder meetings), as well as court cases (Ullibeer 2013).

Inasmuch as techno-economists would like to influence decisions on new energy infrastructure to their favour, the role of policy makers and the political market is quite crucial for two concrete reasons:

- *There are **systemic implications** of the kind of activities we engage in, in energy business.* These systemic implications include *externalities* (Esteban & Dinar 2013) such as: risk of public safety, and pollution. These are termed externalities because the implications of the bilateral transaction between the seller and the buyer in energy business oftentimes have some external implications to third party agents (Zilberman 1999). The effects of these externalities serve as a justification for political influence on the activities in that market.

  Another form of systemic implication is the *network effects* (IEA 2012) which come as a result of the high interdependence in supply (Rinaldi et al. 2001). An example can be the implications of pipeline vandalism which cripple other sectors such as transport or electricity generation due to the high dependence of these sectors on energy supply infrastructure.
- The ***geographically fixed nature of energy resources*** *and the* ***magnitude of investment*** that gets sunk, specific to those geographical locations, constitute another important factor that is specific to energy business and energy infrastructure decisions (Lahr et al. 2010). Once the investments are made and resources sunk in a specific geography, it gives an opportunity for *takings* by political agents. This is what in economics is called *rent seeking* (Brou & Ruta 2013). What happens in this situation is that political agents try to renegotiate the rules after huge investment have been made.

The aforementioned point's to some of the foundational reasons as to why – over time – politics, and the political processes and systems, have gained more importance as key overriding factors in the decision making for new energy infrastructure. Political markets are very critical in energy decisions (Fligstein 1996; White 1993). As such, there is certainly some value in understanding how participating in rulemaking activities and debates over permitting activities and legislation affects the energy market and energy infrastructure provision.

2.2.3. Implications of policy decision making using the techno-economic paradigm.

Policy-making is a very important process in advancing the affairs of every nation, institution, or community. The orientation of each policy maker influences and impacts on the practice of policy-making, as well as the actions and underlying mechanisms of the policy-making system and process. The individual biases of each policy maker are also important. Some policy makers act as rational actors. For them, they only support policies, bills and programs whose benefits outweigh the cost. If the benefits do not outweigh the cost, they do not support it. They think and act more like economists. For them, it is essentially a question of cost benefit analysis and rational choice.

However, as I have implied throughout this wider section on the techno-economic paradigm, the situation is not a simple one. For example, do governments always go for the cheapest option? What happens if the public disagrees? Aside the public, what do other policy-makers think? Are all of their decisions based on economic indices only? If this perspective even considers society in any way (which is debateable), then it would assume that society is organised by economic processes. Does this perspective sufficiently question what underlies or underpins energy demand, and thus why we even need a certain level of supply? These questions seem not to be answered sufficiently when viewed from the techno-economic perspective.

2.2.4. Summary

In this perspective, rational choices that are said to underpin economic processes were explored in connection with energy infrastructure supply. This perspective gives an understanding of the increased role of techno-economic processes in decision making on energy supply infrastructure. The role of politics and the political decision making process is becoming very evident in economic decisions and government's role in energy infrastructure decisions is on the rise. As such, it is important to examine these linkages and their impact on energy infrastructure supply.

2.3. SOCIAL PSYCHOLOGY AND ENERGY INFRASTRUCTURE.

In exploring this perspective, a demand-side approach to energy infrastructure supply provision is adopted. The primary reason for approaching the social psychology of energy infrastructure from a demand side is because social psychology literature is dominated by study on energy demand rather than energy supply. Thus, this perspective looks at how social psychology affects demand for energy, and the corresponding impact that they have on energy supply provision. However, I will draw lessons from the demand-side approach to explore energy supply issues later.

This perspective argues that the provision of new energy infrastructure is a result of what people think (beliefs, attitudes and values) and their psychological makeup. It argues that people have developed habits over time, which tends towards a greater consumerist culture, thus, increasing demand for energy. Since energy is embedded in our culture, this perspective further argues that most of our habits, over time, have become more energy intensive and stresses the need for more energy efficiency and energy conservation. This would, for example, result in the need for less energy supply infrastructure through a reduced demand for overall energy supply.

2.3.1. Overview

Lowering energy consumption can be achieved through energy conservation or energy efficiency (Bohdanowicz et al. 2001). Energy conservation entails modifying a task to achieve it with less energy (Abrahamse et al. 2005). Energy conservation, which can take the form of walking or cycling to a destination rather than drive there, or not using air conditioner in one's residence, helps in reducing the need for new energy supply infrastructure. Energy efficiency entails accomplishing the same task with less energy in a much more innovative way, which could take the form of use of different lighting technologies (such as Light Emitting Diodes – LED technology), or driving a simple car that consumes less energy. Energy efficiency (Häner et al. 2003) has financial gains for the consumers, societal gains for the environment, and reduced needs for building new power plants for utilities. This is important as energy efficiency and energy conservation impact on reduced need for energy supply infrastructure.

Energy conservation (Eluwa & Siong 2013; Stern 1992) is in everyone's best interest. It is good for the economy, national security (Edomah & Nwaubani 2014), the climate, and a host of other goods. The fact of energy conservation is a *no-brainer* for policy makers; however, it is not an easy task for most energy consumers (Wüstenhagen et al. 2009). Every little bit of action does count towards energy conservation (Midden & Ham 2008). The following sub-section delves into the interaction between social psychology, energy behaviour and energy infrastructure provision.

2.3.2. Social psychology, energy behaviour and energy infrastructure provision.

For most consumers, energy is invisible and intangible, just like air. It is not used directly and it permeates every aspect of our lives. Its use is habitual and unconscious (Abreu et al. 2012). It is rarely thought about, but mostly considered when energy bills arrive (McMakin et al. 2002). Unlike other bills, it seems to most consumers that there is no direct link between energy use and cost (Linn et al. 2014). It is unintelligible and complex. The meters and metrics for measurement are unfamiliar to energy consumers. A myriad of devices use energy, such as: mobile phones, home heaters, etc. It is a relatively insignificant subject for most consumers, and they view the monetary value (in relation to the incentives derived) as too small when compared with other bills. The challenge still remains that energy is deeply embedded in our culture through the various cultural contexts of families, work life, and communities. It enables things that confer psychic benefits, such as attention and status. It is impacted by political orientation, values and norms, etc. In fact, it is quite complex from a consumer point of view and it is not fun or interesting to think actively about energy conservation (Prindle & Angel 2010). This has greatly contributed to increased demand for energy which impact on increased need for energy supply provision as many energy consumers are not ready to change their consumption patterns and behaviour.

The traditional approach towards achieving energy conservation has been technology, through various technological innovations (Braun 2011; Grubler 2012). Another approach is through standard economic theory, which assumes that all people are rational; that they make decisions by weighing the cost and benefits of options; that they act in their self-interest, which underpins the techno-economic paradigm (Stern 1992) (section 2.2). In order to achieve energy efficiency, it is argued that all that needs to be done is to give information (such as “saving energy saves money”), or create motivation (mainly through financial incentives), or improve technology designed by engineers. All of these resulted to some good success, but there is still a large gap between what is cost effective and what is actually being done. This underpins the techno-economic paradigm; however, the social psychology perspective aims to do more through a better conceptualization of the influences that surround the individual. Thus, it is argued that human behaviour and beliefs has certain impacts on energy efficiency, which poses certain barriers to its adoption, and as such, impact more on increased need for energy supply infrastructure (since a large majority of energy consumer still have not managed to embrace energy efficiency/conservation measures). For example, four major psychological diagnosis that affect energy efficiency technologies, which in turn impact on increased need for energy supply infrastructure are described below (Weber 2010):

- *Many energy choices are automatic and habitual – more like a result of inertia* (Murray et al. 2005; Aarts & Dijksterhuis 2000). Many of our choices have become almost automatic, more like habits. We either turn on the lights or not, or buy an energy efficient appliance or not. These are things we do without thinking perhaps because we have seen other people do them in the same way. Cost-benefit analysis cannot change an automatic behaviour because one will never stop to do the calculations (Tetlow et al. 2013).
- *Fear of problems with new technology – more like uncertainty avoidance* (Dixon 2005). Some people are afraid of change particularly when asked to do something new. The fear that new technologies can come with new forms of hidden hazards or drawbacks that will only be known, over time, leads to a situation where people try to avoid actions that can lead to uncertainties as much as they can. People tend to be a little cautious when they have to deal with new technologies and try to avoid uncertainties whenever possible (Campbell 2011; Rabin 2000).
- *Upfront higher cost looms large, and future savings are discounted – more like prospects theory* (Kahneman & Tversky 2007). The prospects theory tries to describe how people respond to potential gains and to potential losses. It touches more on people's emotional response to losses and gains. Losses looms larger because any kind of product that seem to have a high upfront cost, such as energy efficient products that pays back over time do cost more initially. This discourages people because they are not quite sure if they will still be alive to reap the benefits of the high initial investment cost of energy efficiency measures. Looking at things from a psychological currency perspective using prospect theory, one can say that the initial investment cost is huge, the gains come in small increment over time and in the future, the gains don't have the

same impacts as the initial losses of funds, they get discounted very heavily, and it is not seen – psychologically – as a net positive transaction, that is why people don't do it.

- _Savings too small to be worth the attention – more like diminishing returns_ (Steg 2010). People's attention is limited to energy efficiency measures because they argue that the savings is too small. When they try to add up their monthly savings and discover how little it is in comparison with what their perceived savings ought to be, it discourages them and generally leads to a *business as usual* situation.

Energy efficiency on the demand-side provides less need for new energy supply technologies. However, the aforementioned socio-psychological drivers are key contributors to increased demand for new energy supply infrastructure as many people are not yet open to changing their energy consumption patterns and behaviour (Tidwell et al. 2005). However, how would people respond to changes in energy systems, and what kind of scenarios will people find more acceptable? The next section delves into some of these issues.

2.3.3 Social psychology, policy decisions and energy systems change

Energy systems transformation is highly impacted by public values, attitudes and acceptability. A background consideration is that we will need to change our global energy system over the coming decades, not just because the current energy systems will be reaching their retirement and needs to be replaced, but because we need to do things in a different way (Demski et al. 2015). There are three policy reasons why current energy systems will be replaced in the near future:

- Climate change and the various commitments by different countries to reduce the effects of climate change (Collins et al. 2013).

- Energy security, which is driven by the need to develop energy systems that guarantees continuity of energy services (Cherp 2012).
- Affordability, which is driven by the need to make energy cheaper for the end user (Centre for Social Research and Evaluation 2010).

The three aforementioned policy reasons is often referred to as the ‘policy trilemma’ around energy systems change because addressing one may lead to difficulty in addressing the other (Tomei & Gent 2015). There is also a fourth driver of energy systems change, which comprises the non-climate change externalities, which deals with environmental issues and people’s perception of the environmental impacts of energy systems change (Ara 2016; Tsoutsos et al. 2005; Akella et al. 2009). For example, covering an area with a number of wind turbines will have some implications for the local environment, the people’s perception of the landscape, as well as potential aspects of the landscape. These are environmental issues to be taken into account, which evolves from people’s values of the land and resources around them (Rowley & Scott 2012).

Current thoughts on energy systems change tolls the line of *whole systems transformation,* which means thinking about how the whole energy systems might change, and the type of energy systems change that are likely to occur in the future (Parkhill et al. 2011). To meet our policy goals of energy systems change, there will be a need to change things on the supply side, i.e., production of more renewable energy and new technologies to achieve that, as well as demand-side changes, such as, the way we travel, the manner we provide energy in our homes, etc.

In studying different scenarios of change with respect to energy systems, lots of people are implicated at various points, either as energy producers or consumers, as proponents and protesters (as is the case with some countries where nuclear power is highly objected, particularly since after the major accident in Japan), or votes by citizens for a certain political party that promises particular policies around energy. On the demand side, people also respond differently to particular changes in energy systems, such as use of smart metering in the home, electrification of transport, and other technical changes, which require citizen and consumer buying if the actual changes are to be realized in a way that saves carbon and meets the policy goals (Parkhill et al. 2011).

The next section, delves into the relationship between social psychology (specifically attitudes) and political cultures.

2.3.4. Social psychology, attitudes and political cultures

Attitudes generally vary across populations. However, behaviours and attitudes may not necessarily correlate well. Generally, in terms of demography, older people tend to be more conservative about change than younger people and women tend to be more risk-averse than men (Campbell 2011). It is precisely the impact of attitudes on energy use that has led to increased demand (and then supply) of energy infrastructure (Schock et al. 2007). The increased consumerist tendency of individuals - which is a result of habits, beliefs and values - is a contributing factor to increased energy use which imparts the increased supply of energy infrastructure.

Essentially, this perspective asserts that just as attitudes influences culture, individual attitudes of policy makers also influences culture in the political sphere. By 'culture', I mean "*those shared beliefs that people learn from society"* (Warren 1999. Pg. 3), and there is much evidence that argues that decision making in politics is influenced by the political culture (Bove 2002). And by 'political culture', I mean "*the distinguishing habits, attitudes and behavioural patterns which characterize a political community"* (Warren 1999. Pg. 5). Whilst the political culture in the United States focuses more on individual freedom, some other cultures may be more concerned with other issues such as collective equality (Menke et al. 2013) – these settings matter for policy decisions that are taken.

Riemer argues that different political systems tend to support different political cultures (Riemer et al. 2010). They argue along the lines on how different political systems deal with the constant power tussle within a nation and how politics (which is seen more as a struggle for power) and political patterns advance accommodation, promote cooperation and resolve conflicts in domestic politics (Warren 1999). These tensions, necessitated by the political culture, also affects energy infrastructure decisions, which can either favour new energy infrastructure provision, or otherwise.

2.3.5. Summary

This perspective emphasizes the role of the individual, their habits, and the impact they have on energy infrastructure supply. It stressed the need for a better understanding of people's attitudes and habits and how it shapes decisions on energy infrastructure supply. Since attitudes are said to influence and drive behaviour (in the political sphere), it is the attitudes and values of individual actors (coupled with organizational values) that shape decisions within institutional contexts and frameworks. Indeed, individual values and attitudes of policy makers are gaining prominence in influencing energy infrastructure decisions. Understanding the increasing role of attitudes and habits of energy end-users and decision makers in energy infrastructure supply can help in the future governance of energy.

2.4. SOCIO-TECHNICAL TRANSITIONS AND ENERGY INFRASTRUCTURE.

This perspective argues that energy infrastructure decisions, as well as technological advances in energy, are underpinned by socio-technical systems. It is argued that it is the organization of these systems that need to be investigated to understand how infrastructure transition, as part of servicing the need of society.

2.4.1 Socio-technical transitions, technological change, and energy infrastructure provision.

Socio-technical transitions represent “a joint transformation of coupled technological and social systems, which enables society to realize benefits from technological innovation” (Hodson & Marvin 2010). These transitions can occur via various pathways, but often require widespread learning and behavioural change (Bolton 2011).

Geels (Verbong & Geels 2007) argues that there are three sectors that are responsible for high energy consumption, which are critical in the consideration of socio-technical transitions: (1) housing and energy, (2) food and drink, and (3) mobility

Geels highlighted that when one considers mobility, one notices that there are several infrastructure that are interconnected in order to ensure smooth and easy mobility (Rinaldi et al. 2001; Ansari & Garud 2009). For example, the use of cars will require more elements to get the car to function (e.g., fuel infrastructure, lifestyles and markets). This reiterates how cars have become embedded in our lifestyles; organized our cities; relied upon for taking our children to school; essential to how we do our shopping; and vital for commuting (Lutzenhiser & Gossard 2000). Geels further argues that industry structure - and therefore massive economic interests - also plays a role in the car industry (especially as the car industry is still one of the biggest industries). Other interconnected systemic influences would include the maintenance networks (when ones car breaks down), regulations, road infrastructure, and cultural dimensions. Essentially, there are a wide range of elements that need consideration if we are to understand the structuring of socio-technical systems (Geels 2006). Figure 2.1 provides an example of socio-technical system for mobility (transportation).

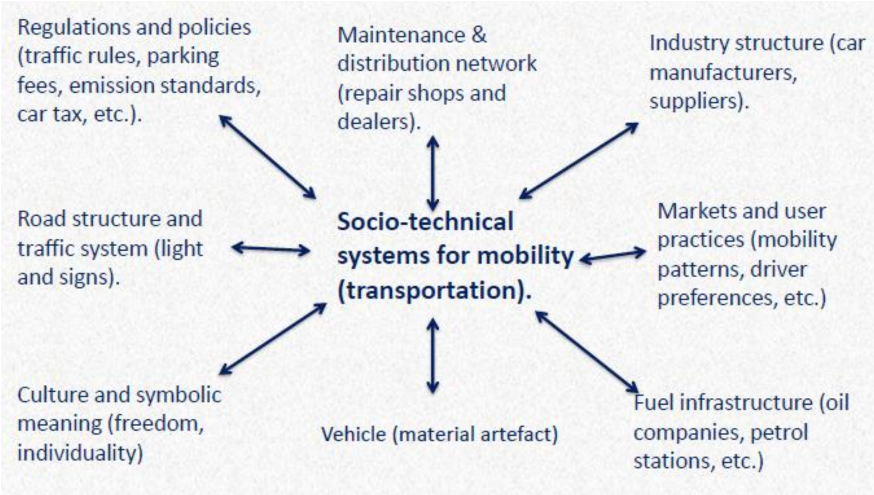

Figure 2.1: Socio-technical system for mobility (Geels 2002). .

Geels and colleagues further solidify their arguments by stating that the kinds of systems we should think of when talking about long term energy transitions (Verbong & Geels 2007; Geels 2011):

- *Decentralize micro-generation + smart grids* – Geels argues that this is not just limited to micro-technologies such as solar photovoltaic (PV) cells, micro wind, heat pumps, etc., but this shift is also about routine things about the consumers, and about people getting more conscious about the things they do. Once people start generating their own power, they become more energy aware, they start thinking about energy in different ways and they start thinking energy conservation (Strengers 2012).
- *District heating + Combined Heat and Power (CHP) + biomass* - This will lead to a shift from our individual heating systems, which is not very efficient, to district heating, where a lot of efficiency can be gained. There will be new infrastructure built in this system, such as piping infrastructure, as well as a new change in billing system. However, Geels argues that this will not lead to a change or a shift in lifestyles but a shift in technology used to achieve the same purpose (Geels 2002).

- *Battery-electric vehicles + smart grid + vehicle-to-grid* – Geels argues that the millions of batteries that are used in cars can be used for electricity if the wind doesn't blow. He further stresses that this would be seen as part of a wider way in which electricity and transport systems are being interlinked. This, he argues, will be part of a wider system change.
- *Inter-modal transport systems or new transport modes* – Geels argues that this will mean going away from the normal modes of transport – which are having bicycles, cars for individual use, trains, trams, or metro for public use – to the use of different ways of sharing, such as bicycle sharing, car sharing, car-pooling, chartered services, and other intelligent ways of generating more transport modes (Geels et al. 2004). This will also translate to shift in ownership, advance bookings, etc.

Technological change tends to involve the improvement of a product or process, which is then used to get a bigger reward for the same amount of work (Rip & Kemp 1998). In this respect, it is then clear that energy systems for electricity generation have undergone technological changes over time. It started (for fossil fuel based systems) with the use of steam engines, then dynamos, internal combustion engines, and later large coal fired power stations and thermal power plants. In the case of renewables, it started with small hydropower plants, later much larger capacity hydro plants, wind turbines, nuclear power, and solar photo-voltaic power systems. Processes or products, such as energy systems, moves through technological change in three stages (Popp et al. 2010):

1. *Invention* – This involves the creation of a new product or process.
2. *Innovation* – This involves the application of the invention for the first time.
3. *Diffusion* - This involves how fast others begin to adopt the innovation.

Following the aforementioned arguments, one can acknowledge that changes in social structures are highly influenced by the technology in use (Hofman & Labar 2007). This is also applicable in the case of energy infrastructure. The provision of certain energy supply infrastructure (say electricity or natural gas) has some impact and influence on people's practices (such as cooking with gas stoves, or home heating using power from electricity). This influence on people's practices (such as cooking) further impacts on the social structures (particularly when such practices become predominant), thus, leading to some sort of pressure on decisions on energy infrastructure provision and technologies that supports and promotes those practices. Thus, the new energy infrastructure provision leads to a situation where there is a shift in technology used to achieve those practices from *niche* to *mainstream* within the fabrics of the existing regime of social structures.

Crest and Boisseuil in their work on 'evolution in energy systems change' argued that traditional principles governing the management and organization of energy systems in many OECD countries is being challenged (Crest & Boisseuil 2012). This is true of electricity infrastructure systems as the organization of most electrical power systems today is based on generation capacity and integration of networks, which all started out in the beginning of the twentieth century as local networks. The traditional notion, according to Crest and Boisseuil that have characterized the coordination of traditional energy systems are:

1. One administrator at a central level takes responsibility for long-term electricity infrastructure planning, provision and balancing demand and supply.
2. Adjusting electricity balance is based on supply-side management which has systemic implications on generation and transmission network infrastructure.
3. Managing electricity demand was achieved through tariff adjustment at certain peak load times.

4. Electricity flow goes from upstream to downstream, i.e., from centralized electrical generation plants to the end customer. The flow of payments goes in the opposite direction.

These aforementioned traditional notions have really impacted on electricity infrastructure provisions across much geography.

2.4.2 How do transitions happen? The Multi-Level Perspective (MLP)

The multi-level perspective (MLP) is one of the most commonly used transitions theories, but not the only one. Here, the MLP has been adopted for the purpose of illustrating the arguments in this section. The MLP has emerged as a result of increased research in transition management (Kern 2012; Geels 2011) as shown in figure 2.2. The MLP focuses on changes in institutional actors and structures over time. Indeed, three analytical levels are considered in a MLP system:

- *Niches* – niches provide a platform for the development of radical innovation, free from excessive external pressures. This is because niche technologies operate at a micro-level with minimal regulatory pressures, which aids the development of new technologies and innovation.
- *Regimes* – this operates at the meso-level. It includes a host of varying number of inter-linked actors from different social groups with varying interests, whose activities are guided by socio-technical rules (Geels 2002). It represents the complex array of interconnected technologies, procedures, infrastructure, practices, and institutions, which governs and constitutes technological change.
- *Landscape* – this operates at the macro-level. It is heavily influenced by a broad range of economic, social, cultural, environmental, geographic, and class pressures. At this level, it is argued that changes occur quite slowly due to the presence of multiple external pressures (Geels 2002).

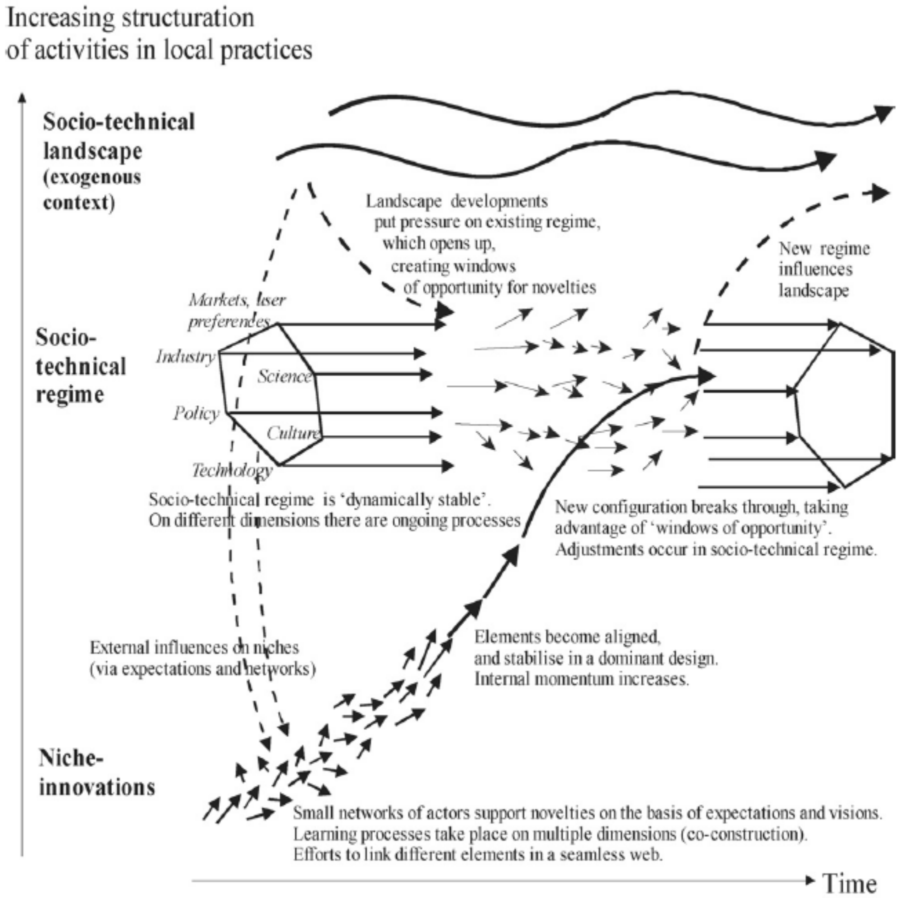

Figure 2.2: Multi-level perspective on transitions (Geels & Schot 2007. Pg. 401)

Geels argues that there are no guarantees that a new novel technology or piece of infrastructure will be used in the mainstream, mainly because of issues to do with experimentation, start-ups and exits, trial and error, loaning, visions and multiple visions, uncertainty about where to go, and the opposition from competing technologies already operating in the mainstream (regime) (Geels et al. 2004). Thus, the point of a transition is that point when the internal momentum is maintained, which is represented by a convergence of social, political, and cognitive interests which leads to an agreement on where to go, which makes investors agree to put in their money in it and hence, make things work.

Momentum arises through: learning by doing, course performance improvement, as well as powerful and influential actors putting their support behind the innovation. This acknowledges the role of powerful individuals – who could be political actors - in decision making. However, Geels argues that this does not happen unless the existing regime starts to fall apart as a result of tensions and cracks, which come through external pressures from a landscape that could include war, oil shocks, crisis, climate change, etc. Geels argues that the whole point of a transition is that you need multiple developments at the same time (Geels 2011). It is not enough to have new innovations and clamouring for change, but one needs to also consider the other external contexts. Table 2.1 shows an example of a MLP, highlighting the various stages in technological development, as well as the mechanisms, cost, market share, and learning rate elements.

Table 2.1. Stylized stages of technological development and typical characteristics (Adapted from Grubler et al. 1999. Pg. 249)

Stage	Mechanisms	Cost	Market share	Learning rate
Invention	Idea & knowledge generation, breakthroughs; basic research	Difficult to attribute to a particular idea/product	0%	Hard to measure
Innovation	Applied research, development, and demonstration (RD&D) projects	High, increasingly focused on a particular promising products	0%	Hard to measure, high in learning (e.g.,> 50 %)
Niche market commercialization	Identification of special niche application; investments in field projects; close relationships between suppliers and users, learning by doing	High, but declining with standardization of production	0–5%	20–40 %
Pervasive diffusion	Standardization and mass production; economies of scale; building of network effects	Rapidly declining	5–50% Rapidly rising	10–30 %
Saturation	Exhaustion of improvement potentials and scale economies, arrival of more efficient competitors into market; redefinition of performance requirements	Low, sometimes declining	Up to 100%	< ¼ 0 % severe competition
Senescence	Domination by superior competitors; inability to compete because of exhausted improvement potentials	Low, sometimes declining	Declining	< ¼ 0 % severe competition

Making transitions happen is a crucial part in the MLP. Lorenz (Lorenz 2007) argues that one can make transitions happen on-the-ground using the following proposed modes of innovation:

- *STI (Science, Technology, and Innovation) mode* – This is the dominant innovation model where we think that innovation is simply Research and

Development (R&D), people sitting in the laboratory developing products, which will be thrown into the market. Basically the core actors are big firms, universities, and research institutes. Geels argues that there is need to shift away from this as this mode has a risk of high disappointment cycles where industry makes beautiful promises about new technologies, which never comes through even after huge money is invested (Geels et al. 2004). Examples of this include smart grids and carbon capture systems, which are yet to be widely deployed considering the level of investment already made, and other related technologies (Gonzalez 2014). They make promises and policy makers do not have the competencies to assess if these promises are valid. From historical transitions, Geels further argues, it takes a longer time for these innovations to be achieved and the result comes out too late when we depend solely on R&D (Geels et al. 2004).

- *DUI (Doing, Using, and Interacting)* – This mode starts by working on concrete systems on the ground. It involves reconfiguring concrete transport systems, energy systems etc. Technological innovation is important here but it does not have to be high-tech, social and institutional innovations are important which will also include a wider set of actors. Cities are not the only ones affected, but also our own particular location where these happens. This mode encourages working together with big firms, policy makers, and consumers (which include small and medium enterprises, engineers) which is done more easily at city level (Geels et al. 2004).

Geels argues that in socio-technical transitions, there is need to carry out the projects in sequences, starting with small ones that require less investment, so as to learn from that experience before embarking on a new (or bigger) one which will serve as a continuation of the previous project, building upon the previous knowledge and experiences (Verbong & Geels 2007). This could take the form of single project or of multiple parallel projects. He further argues that as we progress, over time, the learning with respect to the articulation of the rules and best practices, the cognitive rules, engineering rules, and institutional rules becomes clearer. Geels argues that there is need for transitioning of local projects which can be achieved in the following ways:

1. Using single projects as stepping stones in sequence of projects.
2. Using single projects in context of vision of a wider systems change.
3. Focus not only on direct outcomes (solutions) but also on the learning processes, network building, and vision articulation.

The MLP approach is a useful tool in explaining sustainability transitions. However, the MLP as an approach is now being employed in other areas where it does not perfectly fit. This calls for a need to develop other approaches in understanding energy systems change over time.

2.4.3 Path dependency and energy systems change

It is generally believed that historical decisions affects decisions made today, thus leading to path dependency and systems lock-in.

Arguably, historical events do not take place randomly. Instead, they can be perceived as an emerging property of interrelated circumstances. Path dependence explains how making current decision is limited by decisions made in the past (David 2000). The choices we made in the past influences the choices we make today. Changes in technology, economic institutions and national economy are path dependent (North 1993). Choices made in the past may leave society locked-in with a sub-optimal technology or an inferior standard also referred to as the ‘curse’ of technological interrelatedness (Arthur 1989; Foxon 2002; Klitkou et al. 2015). A major argument why the old systems prevail is that the cost of conversion to a new system exceeds the immediate gains in operating efficiency. This is a key source of technological lock-in.

Path dependency explains how technological and institutional changes in society are partly influenced by decisions and developments in the past, even when the circumstances and events of the past may not seem relevant today. A path dependent process evolves through positive feedback mechanism as a consequence of its own history. It results in self-reinforcing pattern of development (Deeg 2001; Kingston & Caballero 2009).

Indeed, there is also a link between historical energy infrastructure decisions and energy infrastructure decisions made today. This has some serious implications with respect to path dependency and systems lock-in which could take the form of technological lock-in (Perkins 2003; Klitkou et al. 2015) or institutional lock-in (Foxon 2002).

2.4.4 Implications of decision making using socio-technical transitions paradigm.

Policy makers have very important roles in governing transitions in every given society. Some policy makers are neither strict rational actors nor fans of social psychological benefits. For them, they are more concerned about how to ensure that decisions are made, and policies promulgated, that will help aid a quick transition of some available niche technologies, accessible and available to a privileged few, to reach more people. As such, if the provision of a particular energy infrastructure will enable electricity, and other energy resources to be easily and readily accessible to more people, they support it, and if otherwise, they oppose it.

A lot of infrastructure have been (and are still being) provided in many developing economies simply because of the actions and pressure of powerful institutions, governments, and policy makers. A good example is the United Nations, and other international agencies who have – over time – mounted pressure on the need to have increased energy and electricity access for people in the developing world, particularly in sub-Sahara Africa (Gwénaëlle Legros et al. 2009; IMF 2007). All of these pressures have led to significant commitments and the eventual gradual provision of energy infrastructures to help improve energy access. This will lead to a gradual transition to increased energy use and increased comfort levels.

2.4.5 Summary

This perspective stresses the importance of socio-technical rules in effecting energy transitions.. It stresses that how a system is organized determines (to a large extent) the kind of energy infrastructure we end up with. It argues that movement (transition) in technology – and as such, energy infrastructure provisions – is influenced also by social structures and systems. Indeed, this perspective also argues that the way systems have been organized in the past (and historical decisions from previous regimes) leads to path dependency and systems lock-in with regards to the kind of electricity infrastructure we end up with.

2.5 SOCIAL PRACTICES AND ENERGY INFRASTRUCTURE.

This perspective argues that changes in energy infrastructure, as well as the type of energy infrastructure provided, are influenced by changes in practices and social situations. It further argues that the various elements of practices, such as the material, meaning, and competence, play a vital role in the way practices evolve and the corresponding impact they have on energy infrastructure. This perspective moves away from the individualistic notion (as seen in techno-economics and social psychology perspectives) towards a structural approach to reasons for new energy supply infrastructure provisions.

In considering social practices with respect to energy infrastructure provision, a consumption/demand side approach is used. The demand side approach is adopted here because many existing literature have only considered the linkages between social practices and energy infrastructure provision from the demand side perspective. However, the review of this section focuses on people's doings and practices, how it affects demand and consumption of energy and what lessons from this can be drawn to apply to the social practices involved in energy supply infrastructure provision.

2.5.1 Overview

Social practice theory is very different from psychology. Psychology focusses on attitudes, beliefs, and values from the point of view of individual cognition. Practice theory focusses on peoples' (everyday) practices and doings within the social context of the individual. This section focuses on how people's practices affects energy consumption, so lessons can be drawn and applied in the social practices around energy supply provision.

There has been the increasing use of the conceptual framework of social practices theory in the studies of energy consumption (Bartiaux 2012). However, much of the existing body of research on practice theory focussed on practices such as: green practices, daily mobility (Scheiner & Kasper 2003), practices regulating home and household thermal comfort, etc. Shove (Shove 2013) argues that energy is not used for its own sake. It is rather used to achieve some social practices. Warde shows the link between the study of consumption and practice theory by arguing that social practices involve consumption, which is a result of various activities that requires the use of material resources, such as water and energy (Warde 2005). Shove and Pantzar, as well as Warde unanimously agree that there are no generally dominant or accepted lists of elements that constitutes a practice in the entire literature of social practices theories (Shove & Pantzar 2005; Warde 2005).

The works of Bourdieu, Giddens, Shove, and Warde (Bourdieu 1985; Bourdieu & Nice 2000; Giddens 1987; Giddens 1991; Shove 2013; Shove et al. 2012; Shove 2003a; Warde 2005; Warde 2004), forms part of the foundation for the modern study of social practice theory. Structures are the visible patterning of social relations. It encompasses the rules and resources the actors draw upon as they produce and reproduce social activities. Giddens argues that *'systems'* and *'institutions'* do not exist independently of individual activity, rather they only exist insofar as they are continually produced and reproduced via the duality of structure (Giddens 1987). He further argues that structures both *enable* and *constrain* action. Structure exists only at the instance where rules and resources are employed in social activity. Structures only exist in the memory and behaviour.

Practices are *blocks of activities that people share. Many practices require the co-participation of other practices to be performed in a satisfactory way* (Røpke 2009). This means that policy making is also a practice.

2.5.2 Elements of practices and energy infrastructure provision

Social practice is a theory that seeks to determine the link between practice and context within social situations (Smolka 2000). It occurs in the forms of activity and enquiry and most often applied within the context of human development. It involves the production of knowledge, and analysis of both institutional and intervention practices.

Shove and Pantzar (2015) argues that earlier practices theories have previously neglected the role of the *material* in social practices, which are essential and crucial in assessing and analysing the impact and effect of practices on the environment. The *material*, as conceptualized by Shove and her colleagues are made up of technological artefacts and bodily activities. In their analysis, they came to the conclusion that *a practice is a configuration that contains three fundamental components: material, meaning, and competence* (Shove et al. 2012). These three components however should be understood as broad categories without sharply defined boundaries.

The three fundamental components of practices (Shove & Pantzar 2005) define three broad categories of the elements of practices which are: *material, meaning*, and *competence*. From empirical observation, these components encompass more specific elements which are interconnected. Shove argues that these elements, linked within and across these components, forms a block of interconnected elements called practices. Shove further explains the interconnected components by using the example of “going to work”:

- *Material* – This covers all the physical aspects of the performance of a practice which includes the human body. She argues that working is a sequence of bodily activities involving the use of material artefacts, such as using an individual car, pool car, a bus, or a bike. Material also covers all the activities involved, such as buying a ticket, getting to the bus stop, boarding the bus, taking a seat, among other activities.
- *Meaning* – This points to the relevant issues considered with respect to the material, such as: beliefs, emotions, and understanding; issues relating to the available modes of travel to work, such as flexibility, social status, and price. A person travelling by bus regularly may attribute it to the fact of it being less expensive, giving one an opportunity to study, or affording one the possibility of enjoying the company of others.
- *Competence* – This refers to the knowledge and skills required to perform the practice. This includes: knowledge of public transport routes, driving skills, etc.

Anything that is tangible and physical (e.g., our bodies, energy infrastructure, appliances, mountains, lakes, etc.) is included in the materiality element of practices. Therefore, energy supply infrastructure cannot be separated from practices. To study energy infrastructure, using social practice theory, is actually to study how practices have changed over time with respect to energy systems. Energy infrastructure forms part of the materiality component of the elements of practice, and these elements of practice are connected to lots of other elements of practices. Policy making is also a practice, where policy makers take decisions that affect different aspects of the life of society, including decisions on new energy supply infrastructure.

Shove concluded that the components are linked by *individuals* when carrying out a practice. Holtz argues that the *individual* is considered to be an 'empty' container in which meaning and competence are embedded and evolve, and which adopts a material, making the practice, as composition of components, complete (Holtz 2012).

2.5.3 How do energy demand, energy infrastructure, and social practices interact?

Energy infrastructure materializes through the services it provides us (Pierce & Paulos 2010). People generally do not think consciously about the question '*how much energy do you use?*' However, people are more concerned – consciously or unconsciously – about improving comfort, alleviating poverty, and creating a good and just social order which necessarily translates into people embracing social practices, which helps them improve comfort and social wellbeing. This search for comfort and a social just order necessarily impacts on both energy demand and energy infrastructure supply required to carry out some of the predominant social practices albeit the impacts on demand and supply may be different (one impacts energy practice and the other impacts policy practice).

Shove and colleagues developed and made some significant contributions to social practice theory in their work on "*The Dynamics of Social Practice: Everyday Life and how it Changes*" (Shove & Pantzar 2005). This work touches on the fields of consumption and sustainability to which the study of the nature of human behaviour, choices, and actions are important (Hassell & Cary 2007). Shove claims that social practice theory is a response to the ever pressing need to apprehend the nature of social change, while applying that understanding to achieve desired change in behaviour in the areas of sustainability, consumption, equality, among others (Evans et al. 2012; Wüstenhagen et al. 2009). Through that work, they argued and presented the emergent dynamics, transformation, and reproduction of social practices, as well as the constituting elements and links that are bound with social practices. Some of the key arguments which are relevant to the understanding of human consumption include:

- Practices are composed of materials, meanings, and competences (Shove & Pantzar 2005)
- Consumption is just a moment in a social practice centred on achieving other targets (Warde 2005) – which they described as a result of the pursuit of three key targets of convenience, comfort, and cleanliness (Shove 2003b).
- Individuals are not independent agents of rationalized choices but rather merely carriers of various social practices.

The aforementioned postulations have far reaching important implications on how we conceptualize consumption. Holtz argues that within the context of logic, consumption as an end goal does not make sense because it does not have value in and of itself, but rather occurs within and for the sake of other practices (Holtz 2012).

Energy use tends to be taken for granted, and it is unclear how and to what degree members of the public make direct trade-offs between, for example, personal comfort and national imperatives, such as security of supply. Issues and decisions on security of supply are better done within the political sphere as political decisions. Embedded practices, which impacts on rise in energy demand, is one of the contributing factors to the increased demand for more energy supply infrastructure (Higginson et al. 2011). In relation to the elements of practices, energy infrastructure also makes up a part of the materiality element for most practices. Power stations, pylons, transmission and distribution network, etc., help provide the energy needed for ovens for cooking, or computers for policy-making etc. Thus, changes to energy infrastructure can influence practices, and vice versa.

Shove and her colleagues explored the interconnections between energy demand, infrastructure, and social practices (Shove et al. 2015). She explored the etymological roots of the term *infrastructure* which comes from the Latin word "*infra"* which means "*below, underneath, later than, smaller than, and inferior to"* (Shove et al. 2015. Pg. 7). Shove argues that "*it is true that many infrastructure are massive and easy to spot, but whether above ground or below, and whether large or small, in normal use, infrastructure remain relatively invisible"*. Shove identified four shared characteristics of infrastructure and social practices (Shove et al. 2015):

- Infrastructure is often (but not always) *connective* - linking different places and having both entry and exit points and usually more than one of these.
- Unlike many appliances and devices, infrastructure typically sustains a range of different practices at once.
- Infrastructure is generally *collective* - the services they provide are usually for more than one user.
- Infrastructure, are often relatively obdurate.

Shove et al argue that the aforementioned characteristics show how (energy) infrastructure and social practices interconnect.

2.5.4 Summary

This perspective stresses that social structures and individual agents are intertwined. What reproduces or subverts the social structures is repetition of the acts by individual agents. It further argues that elements of human culture must be understood in terms of their relationship to a larger overarching system or structure. Technology (and thus energy infrastructure) is seen as a product of (and an influence of) social practices.

2.6. ENERGY INFRASTRUCTURE PROVISION – INSTITUTIONAL DIMENSIONS

In this section, it is argued that institutions play a very vital role in the governance of energy infrastructure provision. It argues that the individual actors, irrespective of their orientation, exercise their influence in areas of financing, investment, governance, and decisions making, within institutional frameworks.

2.6.1. Overview

In considering the techno-economics of energy infrastructure provision, the argument of Perez was presented that technology, together with its supporting institutions, constitutes a techno-economic paradigm (Perez 1985). Perez argues that the changes in technology cause the introduction of some best practices used in designing social tools for steering institutional change (Freeman & Perez 1988; Perez 1985). Institutional change, as well as the introduction of a new pervasive technology marks the beginning of a new techno-economic paradigm (North 2005). It introduces a strong bias in both organizational and technical innovation, which are increasingly embodied in both software and capital equipment. Perez argues that this cumulative bias tends to lock out alternative technological innovations and trajectories, disguised under prevailing political agenda (Perez 1985; Pérez 2004). Energy issues forms part of the political agenda within many institutions since the governance of energy affects all in varying degree.

The multi-level perspective (MLP) shows that changes in institutional actors and structures do affect and influences transition, particularly through decision making processes that lead to a policy formulation, or public decision (Kunchornrat & Phdungsilp 2012). However, how have institutions emerged? Within what contexts do institutional actors influence decisions that lead to, and supports, changes and transition in energy use and the kind of energy infrastructure we end up with?

2.6.2 Institutional theory and the rise of institutions

Institutional theory is a theory that studies how organizations can increase their ability and survive in a competitive environment by satisfying their stakeholders (Amenta & Ramsey 2010). Institutional factors relate to structures in society. This includes rules, norms, and routines that guide behaviour. These processes can exist within an organization, or the structure may be part of the culture in a particular area.

Meyer and Rowan argues that social processes, obligations, or actualities that come to take on a rule-like status in social thought or actions give rise to institutions (Meyer & Rowan 1977). Institutions constitute the basic building blocks of social, political, and organizational life. They shape choices, behaviour, and perceptions. Institutions include social arrangements, government structure, rules or norms, and ways of thinking in an organization (Hodgson 2006).

Since institutions are not organizations, why do institutions arise? It is argued that institutions reduce transaction costs to meet social needs, that they continue to persist due to cost associated with institutional change, as well as the interests of those embedded within those institutions (Gao 2016). Satisfying the interests of actors within institutions also implies that institutions are not always perfect and efficient. The backbone of institutional theory is survival and social legitimacy (World Bank 2004). There are organizational and environmental structures that work together to achieve some of the ambitious goals set by institutions. However, since structures originate within institutionalized contexts, activities that are commonplace may be taken for granted, which leads to the ceremonial adoption of some policies, rules, products, and services. The existence of external norms, or rationalized myths (Colonial First State 2014), helps organizations in shaping their thoughts to action in their structure with the aim of protecting the technical form of the institution (Georgescu-Roegen 1975). When institutions go through this process, organizational isomorphism is created, which ensures its survival (Findik & Aykut 2014).

Isomorphism is simply the similarity of shape, form, structure, or identity (Beckert 2010). With respect to institutions, it is about similarity in structure of institutions (Meyer & Rowan 1977). There are three major pillars that help institutions to arise, change, and exist. These are:

1. *Regulative* – This operates by coercive isomorphism, using force or threats to ensure compliance to rules and sanctions.
2. *Normative* – This operates by normative isomorphism, which ensures compliance to social obligations, accreditations, and certifications.
3. *Cognitive* – This operates by mimetic isomorphism, which ensures compliance to things that are generally taken for granted, with prevalence as its major indicator.

Within the energy institutions, an example of the *regulative* pillar will be that players within the energy sector involved in resource extraction and production must ensure a safe environment. An example within the *normative* pillar could be the accreditation and certifications by authorized bodies and institutions, guaranteeing that the technical, environmental, operations and technological practices meet the minimum regulatory requirements. The *cognitive* pillar could be that there are qualified professionals involved in the workings of the energy industry (Yu Bao & Houlden 1974).

2.6.3 **Institutions, policy decision making and energy infrastructure supply**

Thinking of how governments go about making decisions naturally raises some questions, such as: does a policy capture the public imagination? Does it tend to benefit the interest of a particular firm or industry over and above another? Does a policy try to shift competitive advantage in ways that benefit domestic firms and harm the profitability of their international competition? In the energy sector, is that the case in terms of energy security, development of resources and infrastructure, or mitigation and adaptation of climate change? (Van de Graaf 2013).

Energy policy issues have a fundamental characteristic which refers to its boundary spanning nature (Cross et al. 2013). Energy policy is not just about energy issues. It is affected by decisions taken in the domains of economic policy, environmental policy, security policy, international relations (more generally), and social policy. Thus, the energy policy field provides much more insights than other policy areas for which there are policy activities. The fact that energy policy is a boundary spanning policy field also means that a large number of actors are involved in energy policy with backgrounds from different sectors, such as economic, security, or environmental backgrounds. This indicates that the wide range of strategies used by these actors should be observed in order to understand their workings (Boardman & Moulton 2011).

2.6.4 Implications of policy decision making using institutional paradigm

Institutions constitute the framework for all the activities of governance. Institutions have defined regulatory boundaries defining the scope of their power. Within those boundaries, there are rules that define the nature of those powers, how they ought to be wielded, and to what effect. This implies that during periods of great change or crises, it is often required to reform or renew institutions

An institution can be any particularly large or important association, an organized or established procedure, or a significant practice, relationship, or organization in a society or culture.

2.6.6 Summary

This perspective stresses the need for governance of energy market and energy systems. This governance is provided by a mix of institutional, public and private actors. It also stresses the need for a better understanding of the institutional frameworks within which decisions, and therefore energy infrastructure decisions, are taken.

2.7. REFLECTIONS.

Following the analysis of the various theoretical perspectives on the reasons for energy infrastructure decisions, I hereby present a summary of the key understanding as follows:

- The techno-economic paradigm reasons that energy infrastructure decisions are all about economic and cost considerations and processes (prices, markets, etc.). For this thesis, I will apply techno-economics in relation with rational decision making based on cost and benefits. In this thesis, there will be a focus on markets as driving technology.
- The social psychological paradigm think it's all about the psychic benefits new changes in energy infrastructure confer which further shapes our energy consumption style. For this thesis, I will apply social-psychology in order to gain insights on what people think (beliefs, attitudes, values and worldviews). In this thesis, there will be a focus on 'what people think' as driving technology.
- Socio-technical transitions perspective argues that it is the socio-technical rules that determine the kind of energy infrastructure that is provided. It stresses that it is how a system is organized that will allow a technology to move from *niche* to *mainstream*.
- Social practice theory argues that socially organized activities/doings, which have evolved over time, are the main drivers of changes in energy infrastructure. For them, practices fundamentally involve technology.
- Institutional theory perspective argues that it is the institutional rules, and the actions of decision makers within institutional frameworks, that determines and

influences decisions on new energy infrastructure. This perspective sees 'institutional workings and rules' as the main driver of technology

Arguably, there are other techno-economic factors which affect energy infrastructure provision in an indirect manner, leading to abuse of laid down market rules and processes which leads to a case of market power. Market power has to do with players or market participants, either individually or as groups, moving prices to their own advantage, which in some way affects the market fundamentals, such as prices, supply, and demand. This is done in such a way as to manipulate the prices in order to make maximum gains from it and move things to their own advantage. From an economic and efficiency point of view that is unfortunate, because it distorts resource allocation as resources are not being used in an economic and efficient way. Inasmuch as techno-economics tend to paint the scenario of the need to have markets that express and show market fundamentals, they in reality, do not respect the rules. As such, it will be quite unfortunate if decisions on energy infrastructure are based just on economic terms and indices since there is also a tendency for politicians to act as rational actors, abuse the rules of the game, and disregard the market fundamentals (Lévêque & Saguan 2012).

Psychological research on energy have focussed a lot on household energy consumption whereas energy efficiency and conservation in organizations, and by employees in organizations, have been less examined (Abrahamse et al. 2005). In most organizations, energy related behaviours are structured by the organization's collective beliefs, culture, values, and identity (Sorrell et al. 2011). Even though many organizations today have made commitments to environmental responsibility and the efficient use of natural resources, existing practices are often strongly entrenched (not only in attitudes, but also in structures, competences, responsibilities and performance evaluation systems). As such, energy saving targets imposed by governments and policy makers help to serve as a check to ensure a shift in organizational (and individual) culture towards a more energy efficient attitude. This relationship between organizational psychology (organizational collective beliefs and cultures) and policy making have been rarely studied by researchers and this constitute a knowledge gap.

Socio-technical transitions theory and systems focusses on the complex interaction between people and technology within social contexts and structures. It also studies how human behaviour and society’s complex infrastructure (which also includes energy infrastructure) interact. It sees and takes society itself as a complex socio-technical system, together with its various substructures. This theory tries to address the technical aspects of organizational processes and (institutional) structures in relation with the social aspects of people and society. This theory does not necessarily see the technical as material technology; rather, it focusses on related knowledge and procedures. It stresses joint optimization with emphasis on achieving quality in people’s lives, and excellence in technical performance. Socio-technical systems focus on the different ways in ensuring that this joint optimization is achieved (Goldthau & Sovacool 2012).

Social practice theory focusses on the motive and intentions of social beings in making and transforming the world with which they live through their doings (practices). It studies the relationship between social structures and individual human agents, thus, seeking to identify the relationship between individual human actions (doings) and some global phenomenon or entity, also known as social structures, context, or system. The social practice theory approach stands between those approaches that focus on social structures/context and those that use methods and approaches that focus only on explaining social phenomena from the point of view of individual actions.

Institutional theory focusses on institutional rules of political actors within institutional frameworks, and how they affect eventual decisions on energy supply infrastructure. It stresses that political actors can either modify the rules of the game, or choose to ignore them. Institutions are important for growth. Institutions include: laws and regulations, cultural institutions, which includes norms around honesty, trust, and cooperation. The way people behave, think, and act is shaped by all institutions that they choose to participate in, such as families, religion, work, group of friends, government, etc.

In investigating the (theoretical) reasons for energy infrastructure provisions, I have explored different strands of literature. In table 2.2, the various perspectives are presented, while highlighting the level with which they tend to operate in practical terms. Techno-economics and social psychology plays more at the *micro* (small-scale) level, where the focus is more on the individual. Socio-technical transitions plays at the *macro* (large-scale) level, where there is a shift in focus from the 'individual' to social structures and contexts. However, social practices and institutions play more at the *meso* (middle) level, which provides a middle ground between the individualistic perspectives (techno-economics and social psychology), and the structural perspectives (socio-technical transitions).

Table 2.2: Theoretical perspectives and their levels of focus

Levels	Paradigms/theory	Focus
Micro	Techno-economics Social psychology	Individualistic approach
Meso	Social practices Institutions	Middle ground between individualistic and structural approaches
Macro	Socio-technical transitions	Structural approach

Table 2.3 shows a summary of the focus of each perspective and how they try to address the issue of energy infrastructure provision. It shows the movement in focus of the various theoretical perspectives from individual cognition towards social context/structures.

Table 2.3: Summary of various perspectives and their focus

Perspectives	Focus		Summary (in relation to energy)
Techno-economics	It focusses on Individuals, markets, prices, and investments with goal-oriented self-interest. It is all based on rational action (choice) in decision making.	Individual cognition	It sees markets as the main technology driver. It attempts to save energy and improve efficiency by focussing on addressing market failures (such as high cost of externalities, transaction costs, and cost of information) by providing cheaper information, new institutions, and incentives. It uses financial instruments, institutions that correct market failures, and information, as intervention tools. Its effectiveness is measured by social welfare and cost effectiveness.
Social psychology	It focusses on individuals (in the context of social norms) It looks at "what people think" – beliefs, attitudes, values, and worldviews.		It sees 'what people think' as the main technology driver. It tries to address barriers to energy (savings and efficiency) by providing feedback and information, as well as (social or economic) incentives in suitable combinations and formats. It uses a combination of information and incentives, as well as innovative informative instruments as its intervention tools. Its effectiveness is measured by behavioural change.
Institutions	Focusses on institutional rules, processes and structures. It focuses on organizational rules within institutional frameworks and structures		It sees institutional workings and rules as the main driver of technology. It tries to address issues of energy through regulations and institutional rules. It uses regulatory instruments as its intervention tool. Its effectiveness is measured by regulatory compliance.
Social practices	It focusses on practices (doings) that are socially organized and have evolved over time. It studies society and social practices		It sees practices as fundamentally involving technology. It is norm oriented, driven by social conventions. It tries to address issues of energy (savings and efficiency) through collective action It looks at change in broader social systems. Its effectiveness is measured by social change.
Socio-technical transitions	It focusses on socio-technical rules, networks and systems of provisions. It studies how systems are organized that makes a technology move from niche to mainstream.	Social context / structures	It sees (changes in) social structures as the main driver of technology. It tries to address issues of energy (savings and efficiency) through reorganization of socio-technical networks, and negotiation. It focusses on determining social movements and social innovations. Its effectiveness is measured by legitimacy and social learning.

The interconnections between policy making and energy infrastructure provisions are often ignored in many researches. Policy makers play a very vital role. As is being experienced in many places (particularly in developing countries in Africa), many good policies proposed have either not been passed to law, or are not being implemented due to the actions of some powerful policy makers and institutions who are not in support of such policies.

What are the influence mechanisms these sort of policy makers and institutions use? (Doukas et al. 2008) The study of these interconnections and how they affect energy infrastructure provisions will be novel (Bale et al. 2015).

2.8. KNOWLEDGE GAPS

In clear consideration of the highlighted points, some vital identified knowledge gaps in current literature in relation to energy infrastructure decisions can be summarized as follows:

1 Few studies have used a combination of different theories in addressing energy supply infrastructure issues. Theoretical pragmatism is rarely used. Theoretical pragmatism is important so that all of the insights gained (as highlighted in section 2.7) can be used to actively shape the problem definition.

2 Most energy transitions studies have emphasized the use of the Multi-Level Perspective (MLP) particularly in areas where they are not useful. Little research has focused on theoretical pragmatism.

3 Few studies have used archival documents for energy transitions studies.

4 Little research has focussed on the relationship between energy supply and policy making. Most studies have focused more on developed countries. Not many researches have focused on developing country context.

5 Considering that little research has been done focusing on developing countries, very few studies have focused on the African context.

6 Studies on the institutional dimensions of energy infrastructure provision are emerging. The dominant perspectives studied by researchers today are more individualistic. As such, any further research that supports the application of the institutional dimensions of energy – particularly within structural contexts - will contribute to knowledge.

7 Little research has been done on the role of technology and institutions - over time - in connection with energy infrastructure provisions. Most of what have been done employ mainly snapshots of technology and institutional dimensions.

8 Research has focussed more on theoretical discussions rather than case study research. For those who have attempted case study research, there have not been many case studies on developing African countries.

Indeed, Goldthau argues that studies need to go beyond studying socio-technical transitions, and towards studying the political economy of energy transitions (Goldthau & Sovacool 2012). The need for empirical research in understanding the role of institutional actors in energy decisions is very important as what shapes the nature and content of energy decisions may have changed over time. Indeed, this chapter will help direct my empirical observations in studying the attitudes and behaviour of institutional actors involved in energy policy decisions (Ajzen & Fishbein 1977). The use of theory as a tool for research investigation helps in three major ways: first, it constitutes that which underpins a research design; secondly, it constitutes that which inform our understanding of the phenomenon under investigation; and finally, it constitutes that which emerges from our study (Creswell 2013).

2.9. ENERGY, CORRUPTION AND THE BLACK ECONOMY

This section on energy, corruption and the black economy has been added, separately from the different perspectives already considered, as a result of the general belief that corruption thrives within the energy (oil, gas and electricity) industry due to the presence of certain economic activities that play out outside the known regulatory frameworks (Ruth 2002).

The black (or shadow or informal) economy comprises those economic activities that falls outside the country's rules and regulations. Depending on the goods/services involved, some of these activities can be termed legal or illegal (Investopedia 2017; Schneider & Enste 2000). The black economy provides the breeding ground for corruption (Jain 2004).

It is generally believed that corruption is one of the greatest obstacles to development. There is a need for a better understanding on how corruption affects economic growth, how it causes shift in allocation of public funds, how it changes incentives and opportunities to investors and entrepreneurs, and how it impacts on market dynamics in different sectors (including energy).

Jain argues that (based on a general consensus) corruption can be referred to as "acts to which the power of public office is used for personal gain in a manner that contravenes the rules of the game" (Jain 2004. Pg. 73). Jain further argues that fraud, money laundering, black market operations and drug trades do not constitute corruption in themselves since they do not employ the use of public power. However, partakers of these sorts of activities oftentimes involve politicians and public officials in order to ensure the operational survival of such activities. These activities rarely flourish without widespread corruption.

Jain (2004) argues that there are three types of corruption that can be identified within a democratic setting as modelled in the relationships expressed in figure 2.3:

1. Grand corruption (relationship 1)
2. Bureaucratic corruption (relationship 2)
3. Legislative corruption (relationship 3)

Grand corruption generally refers to “acts of the political elite by which they exploit their power to make economic policies” (Jain 2004. Pg. 73). Grand corruption has a direct relationship between political leaders and the population. The political leaders are elected by the populace, while they (the political leaders) in turn make public policies in the interest of the population. Corrupt political elite can choose to change a national policy or change its implementation dynamics in order to serve their own interest at the expense of the populace. These political elite ensure that public spending is diverted to those sectors where corruption gains are at its peak, while giving less regard to the collective needs of the populace. The energy sector is a good example of such sectors where corruption gains thrive (Ruth 2002). Indeed, it is difficult to identify this type of corruption since public policy debates may be expressed in terms of public interest. At times, some of these public policy debates are presented in a manner that it is perceived that a larger segment of the society will gain, thus, making this type of corruption difficult to measure and identify.

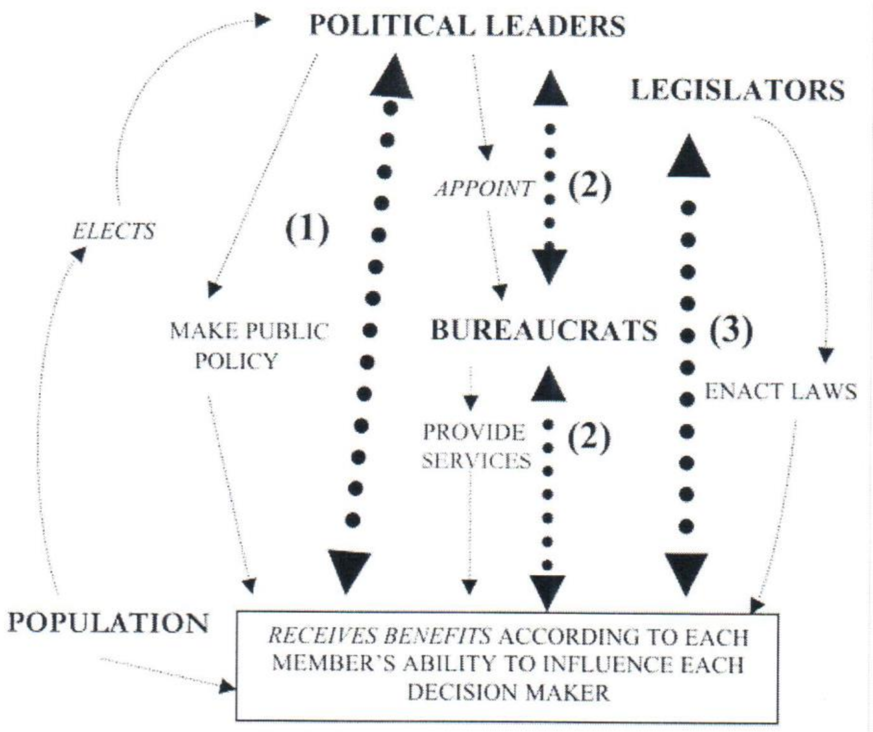

Figure 2.3: Corruption relationship in a democratic setting (Source: Jain 2014, Pg. 74)

Bureaucratic corruption (relationship 2) is defined as “corrupt acts of the appointed bureaucrats in their dealings with either their superiors (political elite) or with the public” (Jain 2004. Pg. 75). This is otherwise known as petty corruption. This form of corruption occurs at two layers. First, it can occur through appointment of bureaucratic actors by the political leaders (such as officials serving in government agencies and ministries as permanent secretaries, directors, etc.). Secondly, it can occur between the bureaucrats and the populace through the services the bureaucrats provide (such as processing permits). In this case, the bureaucrats collect bribes from the public in order to speed up a bureaucratic process or to provide a service. In some cases, bureaucrats collect bribes to carry out tasks assigned to them by the political elite, such as granting permits and licenses.

Legislative corruption refers to the “manner and extent to which the voting behaviour of legislators can be influenced” (Jain 2004. Pg. 75). Several interest groups in a particular sector (such as the energy sector) may choose to bribe legislators to enact laws that will protect their position on certain issues and their economic interests. Indeed, legislators get swayed in this type of corruption (which also includes vote-buying) in their attempt to get re-elected. This form of corruption also plays out within the executive arm of government where officials are swayed in order to ensure certain legislation is enacted.

Indeed, there is also a link between corruption and energy infrastructure supply decisions within the energy industry (Søreide 2014). However, this has not been considered in this review because the link between corruption and energy infrastructure supply is more evident in the oil and gas sub-sector than the electricity sub-sector (Ruth 2002; Gillies 2009). Therefore, corruption is likely to be less dominant in the electricity sub-sector and so the choice of five (5) perspectives remains appropriate. These five perspectives should capture each of the three different corruption relationships at various stages of analysis. At the very least, corruption will be adequately captured through the chosen perspectives if it appears as a dominant driver of energy transition.

2.10. RESEARCH QUESTIONS.

There is a need for more research in understanding, in greater depth, the increasing role of policy makers and the political systems in energy infrastructure decisions. As such, this research is focussed on *investigating the influences underlying past changes in energy supply infrastructure* by answering the following research question:

1. What are the policy making influences on electricity supply infrastructure?

Investigating historical relationship between energy infrastructure provisions and policy making will enable the better appreciation and understanding of factors that have influenced policy making in the past, thus, providing the base knowledge required for future projection of possible factors that might influence energy infrastructure provisions in the future. In answering the research question, three subsequent sub-aims/questions are investigated:

a. How has electricity supply infrastructure evolved over time and what contexts have influenced this evolution?
b. What exactly constitute the practice of policy making, and how has this influenced electricity supply infrastructure provision and energy policy?
c. What are the linkages and consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision?

Each sub-aim highlighted above will be addressed while linking them to the overall aim/research question.

2.11. THEORETICAL STANCE IN ADDRESSING THE RESEARCH QUESTION(S)

In answering the research question(s), I chose to do a hybrid analysis of theories based on the five (5) perspectives already described in this chapter (Dalsgaard 2014; Shalin 1992). Table 2.4 shows a summary of the research question (and sub-questions), the guiding theories used in addressing each question, and some guiding question that served as point of departure in addressing the research question.

In this study, I used theories to explain and understand reality (Creswell 2013). Theories relate with my data as they were used as a tool in generating the guiding questions which aided in addressing the research questions. However, whilst still acting as useful guides in conceptualizing and researching the energy transition 'problem(s)', these guiding questions were used with the ready acknowledgement that the data could contradict and re-guide those initial conceptualizations (i.e., it was an iterative process).

Table 2.4: Summary of research question(s) and guiding theories

Research question	Sub-questions	Guiding theories	Guiding question (point of departure).
What are the policy making influences on electricity supply infrastructure?	How has electricity supply infrastructure evolved over time and what contexts have influenced this evolution?	Social practices	How have social practices impacted on energy supply infrastructure?
		Institutions	How have institutional interventions on energy infrastructure emerged?
		Socio-technical transitions	What led to the changes in energy resource use? Who were responsible?
	What exactly constitutes the practice of policy making, and how has this influenced electricity supply infrastructure provision and energy policy?	Social psychology	What do people (and policy makers) think about with respect to energy?
		Institutions	How do institutions respond to energy infrastructure challenges?
		Socio-technical transitions	What are the influences impacting on changes In energy infrastructure governance?
		Techno-economics	How has cost/benefits analysis impacted on energy infrastructure decisions?
	What are the linkages and consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision?	Social practices	How do government (through the practice of policy making) intervene in energy infrastructure matters?
		Institutions	What are the consequences of the institutional structures on energy infrastructure?

Indeed, institutional theory seems to cut across all three sub-questions as guiding theories in addressing the research aim(s). It provides a platform for the study of the institutional dimensions of policy decision making from both the individual and structural contexts (Young 2003). However, the other perspectives can also offer useful insight into policy decision making and therefore the research approach will draw from each as appropriate. For example, social practice theory could help better understand the social context of the policy maker while techno-economics provides a frame to understand the cost-benefit drivers of particular energy infrastructure. This mix of theory is also offered as a novel contribution to methods.

Part II: Research design

Chapter 3 RESEARCH METHODOLOGY

3.1 INTRODUCTION

A structured step by step approach is required in accomplishing the various tasks needed in addressing the research question. Research methodology is a systematic way of solving a problem (Rajasekar et al. 2006). It is a science that entails the study of how research is being carried out, the methods used, and how knowledge is gained and created. It comprises tools, processes, and procedures used in exploring, investigating, predicting, explaining, and describing phenomena.

This study adopts the use of qualitative and quantitative research methodology tools in answering the research question. Qualitative research is “characterized by its aims, which relate to understanding some aspects of social life, and its methods, which (in general) generates words rather than numbers, as data for analysis” (Bricki & Green 2007).

This chapter focuses on the methodology adopted in addressing the research questions. It also provides the rationale for the choice of the methodological approach (case study), as well as the justification for the choice of this approach. It explores the various research methods used in addressing the research questions (documentary research, and interviews) as well as the tools used for data analysis.

3.2 PHILOSOPHIES OF SCIENCE

This section introduces the concept of philosophy of science, the manner with which knowledge is created, and the three dominant research philosophies in use today. It also states the rationale for the choice of the preferred research philosophy and how the chosen approach will help to satisfactorily answer the research questions.

3.2.1 Background

Arguably, science is the most efficacious way to discover and understand things about the natural world. What makes science so special? How has science managed to work so well? (Forster 2004) That is the central question in philosophy of science. Philosophy of science is a branch of philosophy that studies: how science does things; how it succeeds in what it does; understanding the limits of science; and understanding what sort of questions may, or may not, be applicable to scientific explanations (Uddin & Hamiduzzaman 2009).

Philosophers have proposed and adopted several manner of knowledge creation in order to explain how science works. One argument is that scientific reasoning is ***inductive*****,** that it proceeds from a small number of observations to broader generalizations. We can never tell whether a theory is correct or not no matter how much observation comes from it, because the next observation may contradict it. Indeed, Karl Popper argues that we need to think of new ideas on how science works since, due to objection to reason by induction (Goodstein 2009; Popper 2005). Popper argues that scientific theories can only be falsified but cannot be proven. He stresses that theories are wrong, precisely because there are observations contrary to theory, and hence they have to be abandoned. Popper argues that science is proven by discarding old theories as wrong and not by proving new theories as right (Popper 2005). David Hume, along the same line of inductive reasoning, argues that it is unsafe to generalize (Garrett & Millican 2011).

In ***deductive*** reasoning, one starts with a general type of theory, an idea, or some sort of notion that we have about society, then make hypothesis (Nickerson 2013). Hypothesis is a statement or relationship between two variables that can be tested (Prasad et al. 2001). While we start with the general theoretical idea, we narrow down as we start to think about how we can actually measure this theory. Hypotheses are "*if (this), then (that)*" statements. Once we have the hypothesis, we go on to do the research and collect data, and look for patterns in that data. Once the patterns are figured out, we can talk about our observations and draw conclusions about what those patterns mean.

In a deductive environment, large amount of data are collected that can be analysed statistically (Kothari 2004). The benefit of doing this is that when a good random sample is done, the result can be generalized back to a population. This traditional deductive method works really well when there is a focus on things at the macro level, the big structural forces in society.

Inductive reasoning takes a flip on deductive reasoning, and this is where interactive theorists tend to focus on their method of research (Lichtenstein et al. 2006). Inductive reasoning starts with some observations, looking at what is going on in society, and not a theory of what we think is going to happen (Heit & Rotello 2010). Instead, we go out and look at social reality, maybe taking some notes about what exactly we see out there. There might be a vague or general idea about what is to be studied, but not to go out with preconceived notions about what we want to find, nor do we go with a hypothesis. We let the hypothesis develop as the research unfolds, which then leads to a general theory.

Sociological research investigates and provides insights into how human society operates (Kelly 2011). This could range from large to small scale operations. In sociological research, empirical evidence is used. Empirical evidences are evidences corroborated by direct experience(s) and/or observation (Padian 2007). This form of research provides evidences that can be used to explain the world, as well as to try to prove or disprove a hypothesis. Empirical evidences, together with some scientific methods (used in natural sciences) and theory, together makes up sound sociological research. There is need to have the theory in order to better refine the lens through which to see the world with. Table 3.1 outlines the three dominant research paradigms/philosophies of science and their related assumptions which is treated in more details in the subsequent sections.

Table 3.1. Dominant research paradigms and their assumptions (Capella University 2014)

Assumptions	Positivism	Interpretivism	Critical realism
***Ontological* (nature of reality).**	Fixed, stable, observable, and measurable.	Multiple realities that are socially constructed by individuals.	Flexible. Adopts multiple perceptions in the study of a single reality.
***Epistemological* (knowledge).**	Gained through scientific and experimental research. Knowledge is objective and quantifiable.	Gained through understanding the meaning of the process or experience.	Gained through a combination of scientific and experimental research, as well as people's experiences.
***Axiological* (role of values).**	Emphasis is on the objective researcher, value free; subjectivity and bias lead to error.	Researcher's subjective values, intuition, and biases are important; learning participants' subjective ideas valuable.	It adopts and emphasizes the use of a combination of both objectivity and subjectivity in research
***Methodological* (research strategies).**	Experimental, quasi-experimental, and non-experimental (e.g., correlation) research. Quantifiable methods only.	Qualitative methods only: phenomenology, ethnography, case study, grounded theory, heuristics, and generic qualitative.	Adopts the use of a combination of both quantitative and qualitative research methods.

This research tries to follow a certain order in attempting to answer the research questions. This order is illustrated as follows:

- *<u>Ontology:</u>* Ontology entails all of reality that exists, independent of whether we have knowledge of it or not (Ritchie et al. 2013. Pg. 4-6). In answering the research questions, it is acknowledged that there is reality that exists which we may not be capable of knowing as knowledge of all available reality is beyond the comprehension of the human mind (Bracken 2010).
- *<u>Epistemology</u>:* Epistemology entails that part of reality that can be known. In this research study, some efforts were made to try to get as much knowledge as possible of the available reality on the subject matter (Dieronitou 2014). One of the ways was through a thorough review of existing literature (Grantham 2010; Salas 2013). The knowledge of things that exists helps us to understand and question why things are the way they are and not in another way or manner. The process of questioning leads to a natural quest to want to find out reasons

behind the working of things, as well as possible solutions to existing identified problems. Thus, presenting the need for a methodological strategy/philosophy into which knowledge of reality can be known.

- *Methodology*: Methodology focusses on the research strategies adopted to find out that aspect of reality that can be known (Singh 2006). The methodology is based on certain philosophical foundations. Positivism, constructivism, and critical realism are the three dominant philosophical paradigms that inform methodological strategies used in trying to find out an aspect of reality that can be known (Scotland 2012). It is the chosen philosophical foundation/strategy that then informs the choice of methods/tools required for data collection in order to analyse what exists in reality that can be known (Rajasekar et al. 2006).
- *Methods*: Methods essentially involve all the necessary research data collection tools used in collecting data. It also includes the choice of the tools used for data analysis in order to better comprehend the knowledge of reality that exists (Sandelowski 2000). The use of the various data collection tools, as well as the analysis helps one to draw conclusions, or see patterns which suggest certain aspects of the characteristics or features of that aspect of reality under study (Ratcliff 2004).
- *Conclusions*: Conclusions are a result of a well ordered quest for knowledge of reality which starts from the acknowledgement of the fact that: reality that exists is beyond what can be known or comprehended (ontology); that some aspects of reality can be known (epistemology); that to know reality, there is need to adopt strategies based on a chosen research philosophy in order to make enquiries about that aspect of reality that can be known (methodology); that there is need to choose the appropriate tools in order to collect data/information of the reality that exists (methods); and draw conclusions and suggestions on what the data collected and the study of that aspect of reality suggests (conclusions) (Bhattachejee 2012).

This research follows the aforementioned pattern in order to answer the research question.

3.2.2 The positivist approach (logical positivism)

The positivist research approach focusses on the nature of social reality as independent of consciousness. It is the most widely used approach in social sciences (Kelly 2011). Those that use the positivist research approach believe that social reality can be studied independent of the researcher, and also that social life can be represented by numbers. They typically follow the rules of statistics to manipulate numbers in order to see if those numbers reflects patterns that reveal features of social reality. For positivists, experimentation is an ideal research for checking and clarifying the effects and causes of relationships.

In relation with research techniques, the positivists tend to use more quantitative research techniques in their research such as: closed ended questions in questionnaires, existing official statistics, and in some cases structured interviews. In situations where experiments might not be possible, the positivists tend to view these data collection methods as approximations of the experiments, seeing them as a starting point from which to begin their own research. The positivists seek precise quantitative measures, test causal theories using official data and statistics, and believe a lot in the importance of replicating studies. They test their hypothesis and theories by manipulating numbers that represent empirical facts. They aggregate value-free science (Mark & Caputi Peter 2001).

Researchers using the positivist approach rely more on deductive methods of enquiry (Nickerson 2013). They gather their answers only after they have finished collecting all the right kind of data they need. They condense all information into numerical and statistical data, which they then manipulate in order to find relationships and patterns.

They emphasize replication within research. For them, replication is the ultimate test of knowledge. Positivists believe that different observers looking at the same facts should get the same results if ideas were specified, facts precisely measured, and the standards of objective research followed.

The positivists approach leads to four major assumptions:

- *Ontological assumptions* (nature of reality) – For positivists, there is one defined measurable, fixed, and observable reality.
- *Epistemological assumptions* (knowledge) – For positivists, what is observable and objective are what constitute genuine knowledge. They see the role of science as important for the testing and expansion of theory.
- *Axiological assumptions* (role of values) – For positivists, they view subjectivity as inherently misleading in itself. For them, objectivity is what really matters.
- *Methodological assumptions* (research strategies) – For positivists, adopting the quantitative research methods such as experiments, quasi-experiments, exploratory and analytical models, case studies, etc., is the only acceptable method to generate valid knowledge.

As should be obvious, such assumptions lead to more quantitative studies, which rely on objective measurement of observable phenomena. The positivists argue that that which cannot be measured cannot be reliably known.

Adopting the positivist approach in answering the research question would mean focussing or researching on a single concrete reality with emphasis on objectivity in research. In finding out the relationship between energy infrastructure provisions and policy making, the use of historical statistical data on energy infrastructure provisions may not be enough. Some questions, such as: why was the infrastructure provided? What led to the demand for such infrastructure? What persons or institutions were responsible for the eventual decision on new energy supply infrastructure? What role did they play in the eventual provision? These questions go beyond what statistical data and objective research can provide. It would be necessary to also find out the role of certain individuals and institutions in the eventual provision of energy infrastructure. Thus, the positivist approach is not suitable enough as a research philosophy in answering the research question.

3.2.3 The interpretive approach (social constructivism)

Researchers that use the interpretive approach believe that reality is socially constructed and subjective. Interpretivists seek the need to address human uniqueness within their research. They argue that social reality cannot be simply studied using the same principles applied and employed in the natural sciences (Teague 2000). They use inductive reasoning within their research, and the conclusions they derive suggests truths but do not assure it. They blend abstract concepts and empirical evidences together with the sole aim of creating new concepts and theories. Unlike positivists, they are not necessarily out to test theories; rather, they encourage and enable the creation of new theories. Researchers using the interpretive approach adopt some elements of the constructivist view of social reality, which denotes that social and human life is based more on perceptions, ideas, and beliefs that people hold about reality subjectively, and less on hard factual objective reality (Maxwell 2010). In essence, the interpretivist feel that people socially interact and respond to the lived experiences based on what they believe to be real, rather than simply what is objectively real. This means that social life can only be understood by social scientists, only if they actually study how people construct their own social reality (Yanow 2013).

Researchers that use the interpretive approach largely use inductive reasoning in their research, as well as idiographic method for data collection rather than homothetic method. In idiographic data collection method - which is a qualitative research approach – the use of specific explanations and descriptions of social reality through symbols, images, open-ended questionnaires, interviews, surveys, pictures, etc. are employed which often represents events and people's actions within social reality (Runyan 1983). The raw data collected usually comprises of idiographic data which are labelled, coded, and categorized, with the aim of identifying patterns, themes, and relationship within the data. The theory develops and the data is collected and analysed, and as the data unfolds. The major drawback with the idiographic data collection method is that it is relatively imprecise, it is context based, and it stands a risk of having multiple meanings since the participants narrate their own experience in relation to the research subject which may not necessarily be the same for all participants. Interpretive researchers are more concerned about the development and creation of a theory which develops and knits together as the research unfolds. Interpretive researches are more qualitative (Elliott & Timulak 2005). They rarely use statistical analysis and the data collected is less standardized.

Interpretivists view social reality as very fluid. They believe nothing repeats itself, and that all moments are unique. They argue that social reality involves testing, constructing, reinforcing, and constantly changing perception shifts which is now embedded in institutions, social as well as cultural traditions. Interpretivists are sceptical of the positivist attempts to produce precise quantitative measures of objective facts driven more by their quest for objectivity (Rowlands 2005). In most cases, replication is not seen as the true test of knowledge by qualitative researchers as the positivists do. This is because positivists think that there is one discoverable reality, which means that when you replicate your study, you will end up with the same findings – constructivists say that replication of the same study across different scientists will likely lead to different findings because of how each 'constructs' the study. Constructivists then create knowledge around consensus, i.e. how similar each scientist's constructions are.

In comparison with the four assumptions in the positivist approach, the assumptions for the interpretive perspectives are as listed below.

- *Ontological assumption* – For interpretivists, there are multiple social realities of attitudes about practices. *Reality* cannot be easily defined by the researcher alone. It is more important to capture the meanings, experiences, and perceptions of those participants.
- *Epistemological assumption* – For interpretivists, the study of participants' experiences can only be captured by hearing what they have to say since they are the ones who lived through this process.
- *Axiological assumptions* – For interpretivists, the types of questions asked are influenced by the researchers' worldviews. The analysis of the findings; extrapolation of themes are also influenced by the researchers' values, personal experiences, and worldviews. At the same time, the values, experiences, and worldviews of the participants interact with those of the researchers to deepen the analysis.
- *Methodological assumptions* – For interpretivists, using a qualitative design and in-depth, face-to-face interviews, with open-ended questions, allows researchers to obtain deep and rich understandings of what these participants experienced.

Adopting the interpretivist approach in answering the research question would mean focussing on collecting data based only on the research participant's experience. This approach employs the use of multiple perceptions in a reflexive manner, and focusses more on researching the multiple views of the research participants which constitutes multiples realities. In investigating the relationship between energy infrastructure provision and policy making, it is not enough to collect qualitative data to understand the *why of things*. It is also very crucial to know the *what*, and *to what extent*, of things. Adopting an interpretivist approach in answering the research question means some objective aspects as recorded in historical statistical records on the Nigerian energy infrastructure provisions, and other associated records which answers the “*what*” and gives a more solid foundation in answering the “*why*” (which the interpretivist approach focuses on) of such provisions will be lost. As such, the interpretivist approach as a research philosophy is not suitable enough in answering the research question.

<u>3.2.4</u> Critical realism

Critical realism is a research philosophy developed by Roy Bhaskar. Critical realism provides principles which describes the linkages between the real world and the natural world (Olson 2011). The principles of critical realism provides theoretical explanations that underpins the development we observe in the real world (Maxwell 2010). Bhaskar argues that there are stratified layers of reality which consists of three primary layers:

1. The real layer
2. The actual layer
3. The empirical layer.

The *real*, according to Bhaskar, are the underlying mechanisms or structures that are responsible for what we can observe. The real cannot be seen, but we can speculate on it in different situations. It is not something that we have direct knowledge of. Perhaps, the reasons why there are so many different views of what is the *real*, of what is reality, is not because there are different realities, but simply because our own ability to understand what is real is limited by ourselves. The limitations have nothing to do with the real, but the limitations that we have. In essence, the *real* refers to those underlying mechanisms which cannot be observed. In relation with the research question, the *real* layer involves the underlying mechanisms (which includes lobbying, selling of issue positions to other stakeholders, etc.) in the decision making process which are not visible to the external agents.

The *actual*, according to Bhaskar, refers to events caused by the mechanisms in the real. We can't observe the real, but we can observe the actual, hence, we can observe what things do. In relation with the research question, the *actual* involves the various institutions of policy decisions such as the parliaments, executive council meetings at federal and state levels, the law courts, etc. It is the activities in these fora that are visible, however, the underlying mechanisms and dynamics that leads to the eventual decisions are not seen.

The *empirical*, referring to observable sense experience, which is the position of the individual (social or natural) scientist actually observing the events in the actual level and then making speculations about the real. In essence, the empirical refers to the position of the observer. In connection with the research question, what is observed are the various voting processes in parliament on a given issue, or the pronouncement by an authority on what needs to be done. It is that part of the decision making process that is observable.

In the 2000s, Bhaskar fine-tuned critical realism and came up with what he called the philosophy of *meta-reality*, which has been referred to by other people as *meta-realism* (Maxwell 2010). The philosophy of meta-reality is basically a way of understanding reality on a somewhat deeper level using critical realism itself. Bhaskar argues that the *real* includes two layers:

1. The *cosmic envelop* or *co-presence* – which shows that things co-exist. It is a world of non-duality.
2. The *demi-reality* - which is basically disunity, alienation, that things do not belong to where they are. Demi-reality can also be seen as some sort of social disorganization.

Bhaskar has proposed co-presence as a solution for demi-reality. He however does not mean that demi-reality and co-presence are stages of consciousness i.e. he is not an idealist who talks in terms of consciousness in many cases (Olson 2011). Bhaskar argues that co-presence and demi-reality are real layers, and actual realities, and not just creation of our consciousness. Our consciousness may be influenced by them, but our consciousness does not create them. They are independent of our consciousness. We observe them relatively, fallibly based upon our ability to observe the events they produce, but we don't actually create them directly. Bhaskar in essence have taken Marxism, and have created what can be referred to a trans-Marxism or a transcendent Marxism i.e. taking Marxism and moving it to a new level (Ehrbar 2007). Marxism in general terms refers to two things: emancipation (or liberation), and domination (or oppression). Bhaskar argues that the key to emancipation is co-presence or cosmic envelop (being united in our differences) which recognizes our unity, as opposed to staying in the condition of demi-reality or disunity. He concludes that the ultimate objective or goal of any project of emancipation is reaching the cosmic envelop of co-presence i.e. recognizing non-duality and singleness that we all connect to one another. This view has been developed by many sociologists into several sociological perspectives or theories, and it holds a great deal of promise (Mark & Caputi Peter 2001).

Critical realism as a research paradigm has elements of both positivism and interpretivism and as such is adopted in answering the research questions (Rajasekar et al. 2006). Critical realism, as a research philosophy, aids more easily the adoption and use of a mixture of methods that helps the researcher to obtain data on the research subject from both the subjective and the objective aspects (Zachariadis et al. 2010). Critical realism concerns itself with the study of multiple perceptions about a single (independent) reality. As such, its adoption will help in answering the research question from both the objective and subjective aspects, thus making the research richer and more comprehensive. This is unlike positivism which concerns itself with a single reality, or interpretivism which concerns multiple realities. Critical realism takes cognizance of values in research, as well as recognizing that perceptions have certain plasticity, thus, recognizing that there are differences in people's perception of what is real, and actual reality itself.

3.2.5 Choice of philosophy of science

Critical realism, as a research philosophy is employed in this research study in order to sufficiently answer the research question. Unlike positivism (Sayre-McCord 1985; MacLennan 2009) and interpretivism (Mills et al. 2006), critical realism acknowledges that there is a real world that exists (ontology), independent of our conceptions, perceptions and theories, while at the same time acknowledging that our understanding of the world is shaped by our viewpoints and perspectives (epistemological constructivism) (Maxwell 2010). Since this research focusses on investigating and understanding the policy making influences on energy infrastructure provisions, there is need to understand, in greater depth, the *real layer* i.e. the underlying mechanisms and structures in the policy making process and how it affects energy infrastructure provisions. There is a need to also investigate the *actual,* i.e. the events caused by the various underlying structures and mechanisms of the policy making process and how they affect new energy infrastructure provisions. There is also a need to observe the *empirical,* which helps us connect the events in the *actual*, to those investigated in the *real layer* (A. M. Clark 2008). Thus, critical realism provides a better philosophical foundation to the study and investigation of the various influences in answering the research question. Figure 3.1 shows the various layers of critical realism.

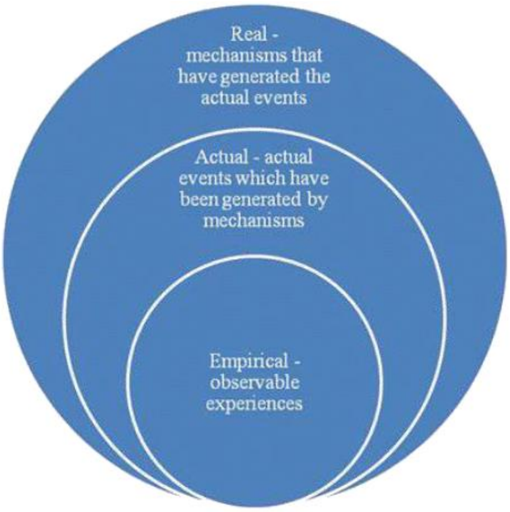

Fig 3.1: A diagram of critical realism. Curled from Mingers and Willcocks (2004)

3.3 ADOPTING A CASE STUDY APPROACH

In the previous section, the dominant philosophies of science employed in research were introduced. The rationale for the choice of critical realism as the chosen research philosophy in addressing the research question was also highlighted. This section discusses the research methodology used in addressing the research question within the context of the chosen research philosophy (critical realism).

3.3.1. Case studies

The chosen methodology of *case study*, together with its associated methods, allows for an in-depth study of a person or group. Baxter argues that case studies involves the analysis of various aspects of the life and history of the subject in order to seek patterns and causes of behaviour (Baxter et al. 2008). Baxter further argues that case studies can be:

- *Explanatory* – Used more for causal investigation (Fielding 2000). This approach aids the researcher to find explanations on the reasons and causes of what and how things are (Scheepers 2003). This approach is good but it is insufficient in answering the research question since it only provides explanations on causes but does not sufficiently link possible effects to causes.

- *Exploratory* – This is often used as a prelude for further in-depth research. It is often used to gather data/information before developing hypotheses and research questions. This approach is quite good as it aids the effective collection of data that can help the researcher to link not only the cause(s), but also the (possible) effect(s) of what is being investigated (Lahoual & Frejus 2013). As such, this approach is adopted in this research to address the research question.
- *Descriptive* – It often starts with a descriptive theory, while data gathered are compared with a pre-existing theory (Harris 1991). The singular use of this approach is not ideal for this research since the aim is not just to gather data in order to test theory, but rather to see how data collected links with the lived experiences of people. However, some elements of description were adopted in this research to provide some background on certain decisions taken in the past.

Zucker (2009) highlights other forms of case studies to include:

- *Intrinsic* – a case where the researcher has a personal interest in the case. In as much as the researcher has an interest in this research, being intrinsically involved as a participant may bring in some biases that could affect the kinds of data being collected.
- *Collective* – this involves studying a group of individuals.
- *Instrumental* – a case where the researcher is allowed by the individuals or group to understand more than what is initially obvious to the observer. Inasmuch as this research does not focus on this approach, some accidental data collected using this approach ends up being quite useful.

Aside the aforementioned types of case studies, there are two methods that can be used in case study research:

- *Prospective* – which is a kind of case study where individuals or group of individuals are observed in order to obtain a desired outcome (Clark 2008). This has an advantage when the focus of the researcher is to obtain a particular desired result. However, this research approach does not help in obtaining information and data on historical everts and actions. As such, this method is inappropriate in answering the research question.
- *Retrospective* – This is a kind of case study that involves looking at historical information. This method provides the platform to investigate and explore historical events, as well as linking them to the current situation(s) (Weinger et al. 2003). This research approach is ideal for this research as it allows one to explore historical events which aid historical data gathering to sufficiently answer the research question.

There have been some misconceptions about case study research as it evolved over time. Flyvbjerg highlights five major misunderstandings about case study research as exhibited by researchers over time (Flyvbjerg 2006. Pg 3 - 4):

1. Some researchers argue that "*theoretical knowledge is more valuable than practical knowledge*". This notion is not quite correct as it is our practical experiences that reinforce our knowledge and appreciation of theories.
2. Some researchers argue that "*one cannot generalize from a single case; therefore the single case cannot contribute to scientific development*". This is also another fallacy as many organizations, institutions, and countries have learnt from the experiences of some particular cases in addressing specific issues.

3. Some researchers argue that "*the case study is most useful for generating hypotheses, while other methods are more suitable for hypotheses testing and theory building"*. This is also erroneous as the study of similar patterns noticed in several individual case studies on the same subject also provides a platform for the testing or building of a theory.
4. Some researchers argue that "*the case study contains bias towards verification"*. This is erroneous as case studies are not designed to verify the researcher's preconceived notions, but rather to discover the various aspects of the subject being studied. Flyvbjerg argues that "*the case study contains a greater bias towards falsification of preconceived notions than towards verification"* (Flyvbjerg 2006. Pg. 21).
5. Some researchers argue that "*it is difficult to summarize specific case studies"*. This can be correct. However, it is less correct when summarizing case outcomes.

In case study research, information can be obtained through various means such as: direct observation, interviews, documents, archival records, physical artefacts, among others. Widdowson (2011) argues that case study (as a research methodology) facilitates the exploratory study of a phenomenon within its context, using a variety of data sources. It enables the issue being researched upon to be viewed from variety of lenses, which allows for a better understanding and revelation of the various facets and aspects of the phenomenon under study. Case study is used in answering the research question, from a retrospective perspective in order to explore, explain, and describe the historical evolution of energy infrastructure provisions.

3.3.2. Choosing Nigeria as a case study

Case study research is one of the various ways of gathering qualitative data. Rowley argues that there are three essential factors that determines the best research methodology to be adopted in a research (Rowley 2002. Pg. 17):

1. *“The type of question to be answered”.*
2. *“The extent of control over behavioural events”.*
3. *“The degree of focus on contemporary as opposed to historical events”*.

Rowley argues that the type of question is the most important factor in determining the most appropriate research approach. Table 3.2 shows the different forms of research questions and the most appropriate methods in addressing them. *“Who, what and where questions can be investigated through documents, archival analysis, surveys and interviews. Case studies are one approach that supports deeper and more detailed investigation of the type that is normally necessary to answer how and why questions*” (Rowley 2002. Pg. 17).

Table 3.2: Choosing a research strategy (Adapted from Yin 1994. Pg.6)

Strategy	Form of research question
Experiments	How, why.
Survey	Who, what, where, how many, how much.
Archival analysis	Who, what, where, how many, how much.
History	How, why.
Case study	How, why.

In summary, a case study research is useful when:

> *“A how or why question is being asked about a contemporary set of events over which the investigator has little or no control”*.
>
> (Yin 1994. Pg. 9.)

The Nigerian case is investigated to uncover the *how* and the *why* of the various influences underlying changes in energy supply infrastructure. This is also supported by archival analysis to uncover *who*, *wha*t, and *where* of those influences. However, why study Nigeria? Why not any other country?

Energy transitions occur worldwide and are influenced by fundamental structural changes in the energy sector (World Economic Forum 2013). Security of energy supply (Cherp & Jewell 2014) remains the most important motivation for global energy transitions such as increasing supply to meet rising demand, as is the case of China (Downs 1995), or .reducing dependency on imports, as is the case of the United States (Leiby 2007). Davidsson, in his study of global energy transitions, argues that *government policy making is the major driver of change* in connection with energy transitions as is the case of Brazil, China, Germany, Saudi Arabia, South Africa, and the United States (Davidsson 2014a). Davidsson argues that Germany and the United States follow a *decentralized* approach in policy making, with a significant impact by state-level policy decision makers. He argues however, that the reverse is the case with emerging economies such as Brazil, China, and Saudi Arabia with *centralized approaches* to decision making where government play a very vital role in defining energy investment priorities. Is this the case with Nigeria, which is supposed to be the most populous black nation (SWAC/OECD 2012)?

In developing economies, energy supply shortages, poor or non-existent infrastructure, and subsidized end-user prices are some key direct challenges which tend to slow-down the implementation of structural changes in energy systems. In industrialized countries, the main challenges are: rapid speed of change, and imbalance in the development path of energy systems (Matschoss 2013). Davidsson argues that:

> *"**The exchange of experiences and the sharing of knowledge gained from solving implementation challenges can make an important contribution** towards tackling the challenge of energy transitions worldwide. The countries analysed can learn from important*

*parallels and differences in terms of **policy making, technology deployment and business model evolution***" (Davidsson 2014. Pg 2.) (Bold added for emphasis).

Following Davidsson's argument, I am choosing Nigeria as a case study in order to:

1. Contribute to the existing body of knowledge by aggregating experiences of Nigeria's past energy transitions since such studies is yet to be carried out.
2. Aside that no such studies have been done on Nigeria, I have also chosen Nigeria because of its fairly long energy history (almost a century now), her increased role as a major energy and economic player in Africa (Iwayemi 1998), and her role as the most populous black nation in the world (SWAC/OECD 2012). South Africa is one of the few African countries where a good amount of energy transition studies has been done.
3. Understand how the policy decision structure has influenced transitions in energy use and energy policy within the Nigerian context, and then compare, if there are similarities or differences, with similar studies already carried out on other countries.

3.3.3. Further background on Nigeria

Nigeria is the most populous nation in Africa. It is also the biggest economy in the region and one of the fastest growing economies in the world. Nigeria has an estimated population of 180 million people, with a total land area of 923,766 square kilometres. Her official language is English, with Igbo, Yoruba, and Hausa as the main indigenous languages. The main religions practiced are Christianity, Islam, and traditional modes of worship (Chevron 2013).

Nigeria is a constitutional federal republic comprising 36 states and a Federal Capital Territory (Abuja). It is located in the West African region, and is bounded to the east by

Cameroun and Chad Republic, to the west by Benin Republic, to the North by Niger Republic, and to the south by the Atlantic Ocean. It has about 800km of coastlines. Nigeria operates a three-tier structure of government – A Federal Government; 36 State Governments; and 774 Local Government Administrators. Some of the main commercial/industrial cities include: Lagos, Kano, Onitsha, Port-Harcourt, Aba, among others. Nigeria's currency is the NAIRA and KOBO N1.00 = l00k (one naira = hundred kobo) (Chevron 2013). Figure 3.2 shows a map of Nigeria, highlighting the regional energy resources for power generation.

In terms of economy, Nigeria is currently the biggest economy in Africa (Leke et al. 2014). The Nigerian economy is driven more by crude oil. Nigeria is the 12th largest producer, and the 8th largest exporter of petroleum in the world. It is the largest oil producer in Africa (US Energy Information Administration 2013). Nigeria has the largest proven reserves of natural gas in Africa, and the ninth largest proven reserves in the world. Nigeria produced 1.2 TCF of dry natural gas in 2012, ranking it as the world's 25th largest natural gas producer. Natural gas production is restricted by the lack of infrastructure to monetize natural gas that is currently being flared.

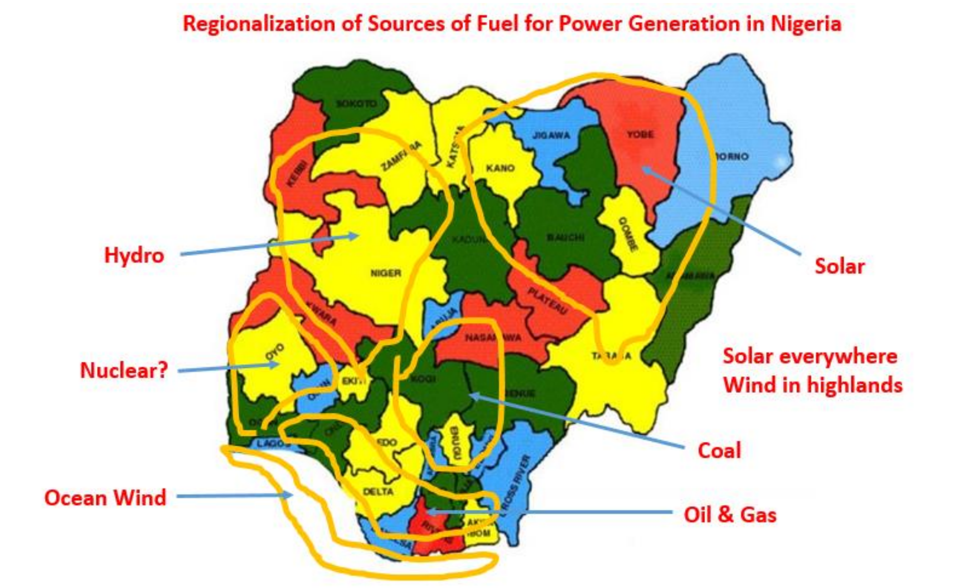

Figure 3.2: Map of Nigeria showing the regional energy sources for power generation. (Source: Nigerian Muse in the article "*The case for an energy emergency in Nigeria*").

The oil and gas industry, primarily located within the Niger Delta region, have been a source of conflict with local groups seeking a share of the wealth via attack of the oil infrastructure, forcing companies to declare force majeure on oil shipment. Loss of production and pollution caused primarily by oil theft (bunkering), leading to pipeline damage that is often severe, is forcing some companies to shut production (Edomah & Nwaubani 2014).

The Nigerian energy sector is very complex. It involves interaction among multiple (state and non-state) stakeholders. Decision making is mostly influenced by domestic politics and other geo-political considerations, which sometimes create lack of clarity that makes companies want to bend the rules in order to stay competitive (Kent & Goatcher 2016; Edomah et al. 2016). Related to this is the issue of bias in the selection process for choosing contractors for a specific project, which is oftentimes introduced before the bidding process. Indeed, this is more evident as a form of corruption in the oil and gas sub-sector than the electricity sub-sector (Gillies 2009).

Why the electricity sector?

The energy sector is very broad. Conducting interconnection studies between policy making and energy infrastructure supply requires that the specifics of each sub-sector is understood. There are two dominant sub-sectors of the energy industry in Nigeria:

1. *Electricity* – This includes generation, supply, distribution and utilization.
2. *Oil and gas* – This includes exploration and production activities, upstream, mid-stream and downstream operations, etc.

Indeed, there are other sub-sectors which are not as dominant as the aforementioned ones (such as coal and nuclear). Focusing on one sub-sector provides a platform for an in-depth study on the core issues associated with that sub-sector. As such, the choice of the electricity sector also considers the various electricity sources and fuels (coal, hydropower, natural gas, etc.), electricity legislation and governance issues, amidst other possible influences. The electricity sector has been chosen for the following reasons:

1. There are salient issues in the electricity sector which impacts on both the rich and the poor (such as energy access and poverty).
2. There are not as much studies done on the Nigerian electricity sub-sector in comparison with the oil and gas sub-sector. One of the reasons for this is that there are more funding from oil and gas firms in Nigeria for research in the oil and gas sub-sector (through postgraduate scholarships and research collaboration for academics) than for electricity.
3. The oil and gas sub-sector is likely more influenced by foreign investments rather than domestic needs and policy dynamics.

3.4 DATA COLLECTION

Research methods primarily entail the various means of getting information and gathering data (Kong 2004). The most common methods of gathering information include: literature searches; telephone, email, internet, or mail surveys; focussed groups, and talking with people.

A *literature search* involves reviewing already published and readily available materials (Liverpool Hope University 2012). These materials can be relevant trade publications, magazines, journal articles, online databases, newspapers, annual reports, company literature, and other published materials. It is an inexpensive way of gathering information; however, gathering information using this method can take some time.

Talking to people is a very important way of gathering information that is not readily available to the public, or that is too new to be found in public literature. This method is a useful tool for gathering information for a research project at the initial stages. Although this method can be very valuable, the information gathered can, on some occasions, be questionable since the views expressed can be subjective and may not reflect the true views of the larger population.

A *focus group*, often used as a preliminary research technique, serves as a good tool to explore people's attitudes and ideas (Liamputtong 2010). It is a good tool for testing new approaches and discovering customer concerns. In this method, the moderator leads the discussion of the group to ensure a focus on the subject to be explored.

Personal interviews are useful tools for gaining comprehensive and in-depth information. It involves the interviewer interviewing the interviewee for personal or detailed information (Hannigan & Meins 2010). What is typical is that the interviewer asks questions from a questionnaire and notes the response and answers verbatim. The questionnaires in this case can take different forms. It can be a list of topics to be discussed with an industry expert. This method can be expensive, but can also be quite effective in the case where participants are likely not to respond to surveys.

Telephone surveys can be a very useful tool for gathering information quite quickly from a very large sample. In this case, the interviewer uses a prepared list of questions that is essentially the same as the written questionnaire (The Wallace Foundation 2014). This is also a useful tool which allows for opinion probing i.e. why the respondent thinks or holds a particular opinion.

Mail surveys can be a very cost effective tool particularly when the participants are located in different geographies. The drawback of this method is that it can take a longer time to complete.

Most studies employ the use of personal interviews, while some adopt a combination of two of three different methods such as focussed groups and personal interviews. This research focusses on the use of in-depth personal interviews in order to obtain the interconnection between energy infrastructure provisions and policy making through the lived experiences of the research participants.

In carrying out this investigation using critical realism as the research philosophical lens, this research study employs some of the elements of quantitative and qualitative research approach. The use of ***mixed method*** is employed in addressing the research question in this study (Graff 2014). Quantitative and qualitative data was collected from already published literatures and official records and statistics in order to ascertain the historical reasons and factors that underpinned energy demand, consumption patterns, and energy infrastructure provisions. Qualitative data was collected through in-depth interviews with current and past policy makers (which include current and past federal and state law makers, ministers, and special advisers to the government). The aim was to collect historical data – based on the participants' life experiences – on the impact and influence of policy making - as a practice – on decisions regarding energy supply infrastructure provisions.

The mixed method is a research design that uses a combination of qualitative and quantitative research approaches in many aspects and phases of the research process (Sandelowski 2000). The mixed method uses a philosophical assumption that guides the direction of the collection and analysis of data. As a method, it focusses on collecting, analysing, and mixing both quantitative and qualitative data in a single study or in series of studies (Kothari 2004).

Quantitative and qualitative datasets can be mixed in one of three ways:

- By embedding one dataset within the other.

- By connecting one dataset to the other.
- Merging or converging two data sets by actually bringing them together.

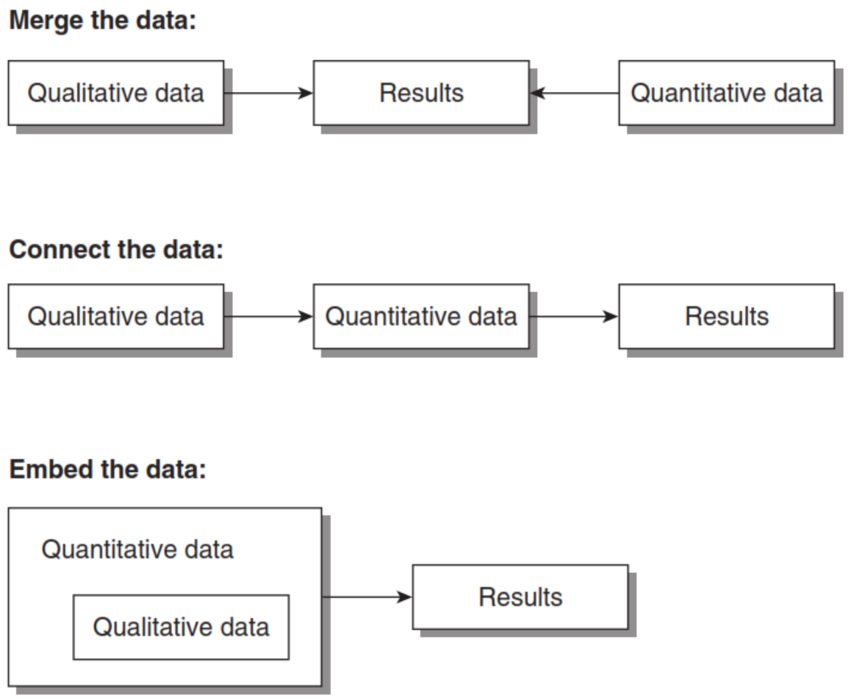

Fig 3.3: Mixing qualitative and quantitative datasets. (Curled from. Creswell (2006). Pg. 7)

Qualitative and quantitative data collected in the course of the research will be mixed by *merging the datasets together* before producing the results (Sandelowski 2000).

<u>3.4.1</u> Choice of research data collection methods

In attempt to answer the research question, quantitative and qualitative data were collected from two broad sources:

<u>3.4.1.1.</u> <u>Documentary research.</u>

Quantitative and qualitative data were collected from existing literature, documents, and archives of various institutions using documentary literature research tools. Scott (2006) argues that documents are texts produced by an individual or group with the exclusive aim of addressing immediate practical needs.. They are written based on particular assumptions and with a clear purpose. In documentary study, there are two types of documents used:

- *Primary documents* - this refers to eye-witness accounts produced by people who experienced the event or behaviour under study.
- *Secondary documents* – this refers to documentary accounts produced by people who were not eye-witnesses of the event or behaviour under study, but who rather received eye-witness account to compile the documents, or have read eye-witness accounts (Johnston 2014).

Quantitative and qualitative data from primary and secondary sources in documentary archives and other published sources that links to the Nigerian historical energy infrastructure provisions were used for analysis in order to have a better understanding of the Nigerian energy (infrastructure) history. Table 3.3 shows the various sources of documents which served as the basis for the analysis in addressing sub-questions 1 and 3 as presented later in chapters 4 and 6.

Table 3.3: The sources of documents used in addressing research sub-questions 1 and 3

Thesis chapter	**Document sources used**
Chapters 4 and 6 (addressing sub-questions 1 and 3)	Diaries, letters, memos, and memoirs contained in the detailed account of Francis Jackel covered in the following volumes of the history of the Nigerian Railway: Francis Jackel (1997) "History of the Nigerian Railway: Opening the nation to sea, air, and road transportation". Vol.1. Spectrum Publishers. (Out of print). Francis Jackel (1997) "History of the Nigerian Railway: Network and infrastructure". Vol.2. Spectrum Publishers. (Out of print). Francis Jackel (1997) "History of the Nigerian Railway: Organization, structure, and related matters". Vol.3. Spectrum Publishers. (Out of print). Other historical policy documents
Chapter 4 (addressing sub-aim 1)	Organizational reports of the United States International Energy Agency (IEA) and the Energy Information Administration (EIA) as contained in the following selected documents: IEA, 2012. Energy Technology Perspectives 2012 Pathways to a Clean Energy System. *Internationaal Energy Agency*. IEA, 2011. IEA analysis of fossil-fuel subsidies. *World Energy Outlook*, IEA, 2014. Speical Report: World Energy Investment Outlook. *International Energy Agency*. EIA, 2015. Country Analysis Brief: Nigeria. *US Energy Information Administration*.
Chapters 6 (addressing sub-questions 3).	Other policy documents from various regulatory agencies in Nigeria were also used. These included: • Handbook on application for licenses (and related licensing/permits forms) (NERC 2010) • Nigerian electricity smart metering regulations (NERC 2015) • Nigerian electricity supply and installation standards regulations • Regulations on embedded generation • Regulations on national content development in the power sector. • Regulations on procedure for electricity tariff reviews in the Nigerian electricity supply industry • Regulation for captive power generation • National energy policy document • Guidelines and requirements for oil and gas industry service permit • Requirements for obtaining offshore safety permits • Guidelines for the importation of petroleum products into Nigeria • Guidelines for bunkering operations in Nigeria • Statutory guidelines for the operation of coastal vessels Some of these policy documents can be found on the website of the Nigerian Electricity Regulatory Commission (NERC).

It is noteworthy that in many existing transition studies, one can easily notice the extensive use of quantitative (and qualitative) data from published literatures, and particularly archives of some agencies, used in collecting data and making meaningful analyses which serves as pointers, suggesting various constitutive elements of the energy history under study. This research does not only focus on collecting archival records, but also tries to validate and enrich the data through collection of qualitative data via personal interviews from people who have also been involved in the energy history. See appendix 6 for some extracts of documents used for data collection.

Why choose these documents?

These set of documents were selected for analyses for the following reasons:

1. The Nigerian Railway Corporation is the oldest institution in Nigeria which has existed since colonial times (in late 1800s). They hold some of Nigeria's oldest archives.
2. The archives of the Nigerian Railway Corporation (NRC) contain records of associated events that led to decisions on the provision of several rail infrastructure. Some of these documents contained the reasoning (and contexts) behind those decisions and the future benefits the government aimed at achieving. An example is the case of providing rail infrastructure linking Kano to Lagos to aid the easy movement of agricultural produce from the hinterland (in the north of Nigeria) to the ports (in the south of Nigeria) for export (Francis Jackel 1997b). Some archival documents from the NRC provided details on the institutional, socio-political, trade and policy contexts on infrastructure decisions taken. I was allowed to make photocopies of some parts of the archival documents which were used for my analysis later on as evidenced in appendix 5.

The documents collected and analyzed served in addressing the first and third sub-questions of this research which provided the bases for the results and analysis as presented later in chapters 4 and 6.

3.4.1.2. In-depth interviews

Qualitative data were collected via in-depth semi-structured interviews with open ended questions (Laforest 2009). Semi-structured interview was adopted so as to ensure that the vital aspects of the research question are covered while still giving room for discussions which could provide more insights into other aspects which may not be directly linked to the research question, but could be very vital in the research (Zorn 2008). The qualitative data collected had the following features:

Aim - was to gather historical data - based on the lived experiences of the participants - in order to ascertain the policy making influences on energy infrastructure provisions, with particular emphasis on the electricity sector. The interviews conducted served as the basis for addressing the second and third sub-questions of this research which were later presented as part of the results and analysis in chapters 5 and 6.

Establishing the sample frame

In establishing the sample frame, the following process was followed:

1. *Identifying the population of interest*: In the case of this research, the population of interest were those people who have been involved in the process of policy making (directly or indirectly) relating to energy and electricity infrastructure supply in Nigeria.
2. *Specifying a sampling frame*: This is the group of people from which the sample was drawn. In the case of this research, the sample was drawn from the population as established in table 3.4.

3. *Specifying a sampling method*: The selection of the samples was done randomly within each group of possible participants as established in table 3.4. This method was adopted in order to ensure the sample is representative of the population.
4. *Determine the sample size*: Larger samples are better inasmuch as they require more time and effort. In this research, the sample size was 12 (table 3.5). This is because these were the participants that agreed to take part in this study. It is noteworthy that the sample size was representative of the population as highlighted in table 3.5.

Target participants - The target participants for the interview were people who have been involved in policy making (either directly or indirectly) in the past, and those who have been involved in specifying the technical requirements, as well as maintaining existing electricity infrastructure, with specific focus on people from age 50 and above. The choice of the age limit is buttressed by the fact that the research aimed to get more qualitative data as far back as possible. The participants were composed of two groups of people which are:

- Those who have been involved either directly or indirectly in the policy (formulation or implementation) process.
- Those who have (either directly or indirectly) been major stakeholders in building, maintaining, or prescribing the technicalities of the historical electricity infrastructure which forms part of the Nigerian energy history

On the part of policy makers, emphasis was placed on the following categories of people:

- Current and past policy makers who were members of parliament at the federal (country) and state levels.

- Current and past directors and permanent secretaries of relevant government ministries and parastatals.
- Current and past special assistants, ministers, advisers and consultants to government.

The research participants came from diverse backgrounds. Samples of the roles of some of the research participants include:

- Members of the federal and state houses of assembly. The participant with the minimum experience in this category had 12 years legislative experience.
- Special assistant/adviser to the president on policy implementation.
- Directors of some important government agencies and parastatals, such as the Nigerian Electricity Regulatory Commission (NERC).
- General Managers (GM's) and Chief Executive Officers (CEOs) of some power generation plants and distribution networks such as the Transmission Company of Nigeria (TCN), among others. The average experience of the participants in this category that were interviewed is 20 years.

Recruiting participants – As earlier highlighted, participants were recruited mainly from people who have been involved (directly or indirectly) in policy making and electricity infrastructure provisions. The following outlines the process followed in recruiting the participants:

Identifying the participants - Indeed, two theoretical lenses of institutions and social practices had direct influence in the identification and recruiting process for the research participants. I specifically wanted diversity of these two main dimensions:

- *Institutions*: within what institutions do these participants exercise their influence and take decisions on electricity infrastructure?
- *Social practices*: what do these participants engage in? What sort of activities take up the bulk of their time while exercising their professional duties?

A list of some possible participants was initially compiled. This list was obtained from the websites of some important government ministries and parastatals. The focus was on those ministries, parastatals and committees within the parliament whose roles interface with energy infrastructure decisions and policy formulation and implementation. Table 3.4 shows an initial list of government agencies, ministries, parastatals and (public and private) institutions generated, as well as the target position of interviewees. The idea was that the interviewees were to come from such institutions.

Table 3.4: Initial ideas of institutions for target interviewees (sampling frame)

Roles/expertise	Institutions
Policy experts and lawmakers.	Federal and State Houses of Assembly (and their committees) • House committee on treatise, protocols and agreements • House committee on Power • House committee on Sustainable Development Goals • Lagos state house of assembly
Current and past special assistants and advisers to (current and past) presidents and state governors	Federal and State government house(s)
Current and past (technical and non-technical) directors of various institutions under the electricity sub-sector	Electrical transmission companies • Transmission Company of Nigeria Electrical distribution companies • Abuja Electricity Distribution Company • Benin Electricity Distribution Company • Eko Electricity Distribution Company • Enugu Electricity Distribution Company[4] • Ibadan Electricity Distribution Company • Ikeja Electricity Distribution Company • Kaduna Electricity Distribution Company Plc • Port Harcourt Electricity Distribution Company Electrical generation companies • Egbin Power PLC • Ijora Thermal Power Station • Coronation Power & Gas • Olorunsogo Power Plant
Senior technical experts	Electrical power Original Equipment Manufacturers (OEMs): • Schneider Electric • General Electric • ABB • Siemens

An initial list of 25 people to be interviewed was generated that had representation from various institutions outlined in table 3.4. The initial list was generated by targeting a maximum of two roles within each organization that falls under the broad target categories. The target categories were: policy experts and lawmakers; special assistants/advisers to presidents/governors; current and past directors of institutions responsible for electricity supply infrastructure; and senior technical experts from private Original Equipment Manufacturers (OEMs). Indeed, only 12 were interviewed.

The 12 that were interviewed represented similar organizations and covered the four broad areas of interest as outlined in table 3.4. However, some individuals covered more than one organization. For example, one of the interviewees had worked as a special assistant to one of the state governors in the past before becoming a federal lawmaker. Table 3.5 shows the distribution of the final interviewees.

Table 3.5: Distribution of interviewees

Industry roles/expertise	**Number of interviewees**
Federal and state houses of assembly (and house committee) members	2
Transmission Company of Nigeria	2
Distribution companies	2
Generation companies	2
Current and past special assistants to president(s) and state governors	2
Senior experts from OEMs	2

Contacting prospective participants – Considering the cultural context of Nigeria, this step in the process had to be handled with utmost care due to the high profile level of the target participants. As such, I had to identify mutual close associates and friends of the target participants. I got the mobile number of each participant and sent them a short message via Short Message Service (SMS). A sample of the message reads as follows:

> "*Good afternoon Hon. Philip. I am a PhD Researcher in the field of Sustainable Energy. I will be pleased to have an interview session with you in line with my research. I got your mobile number from a friend. I hope to call you much later to give you further details. Norbert"*

Surprisingly, this approach worked quite well, as all those contacted actually did respond and showed keen interest to participate in the research. They got enthused by the fact that it is a doctoral research, and that the research subject matter seemed very relevant and tries to address the current Nigerian situation. This initial SMS was followed by a telephone conversation where the aims and objectives of the research were clearly mentioned to the participants. Upon initial consent to participate in the research, we then agreed on a possible date, time and venue for the interview. Table 3.7 shows a list of some of the research participants interviewed, their background, areas of expertise and the dates the interviews were conducted.

Role of recruiting Personal Assistants (PAs) – Recruiting personal assistants of the core research participants I wanted to interview was not in the initial plan of research. However, as the research progressed, I saw the need to recruit them as major stakeholders in ensuring that the interview schedule was included in the plan of the research participants. For those target research participants whose contact I could not get, I walked into their offices, explained to the personal assistant my reasons for wanting to meet with their boss, and I drop my contact details. Some of them called me within 48-hours, expressing their boss' intention to have a chat with me to schedule an interview date and time, while some preferred to give me the mobile telephone numbers of their boss for me to have a direct discussion with them. Recruiting personal assistants was quite helpful in the research process.

Interviewing the participants – At the beginning of the interview, I made it clear to the interviewees that some things are essential to have a smooth interview: The participants were given a copy of the Participant Information Sheet (PIS) (see appendix 1) and were informed about the need to sign a copy of the Participant Consent Form (PCF) (see appendix 2) showing their consent to participate in the research. They all complied with this requirement. Owing to the cultural context of Nigeria, where public figures can be quite conservative when they are aware that what they say is being audio-recorded, I ensured that no audio/video recordings of the conversation were made. However, I took notes using pen and paper during each interview. This is quite crucial as this gave the participants much confidence and led them to extend the time of the interview (at their request) beyond what was initially agreed. It is noteworthy that within the Nigerian context, many public figures fear that what they say may be put out of context and misinterpreted when the speech is audio-recorded, while a part of the content of the speech can be used as evidence for that. This is the main reason why I ensured the interviews were not audio-recorded. The participants did show very keen interest in knowing the outcome of the research and have requested that the results be shared with them. However, it is noteworthy that at the advanced stage of data collection period, there was a season of mass probing of government and quasi-government office holders in Nigeria. This led to research participant's apathy towards speaking with anyone in the name of 'conducting a research'. However, I was fortunate that during that period, I was already reaching 'theoretical saturation' as regards the kind of data being collected. See appendix 7 containing some extracts from the interviews conducted.

Kind of questions (interview protocol) – The questions were open ended questions centred on different themes. The participants were encouraged to give a reflective narrative on how they (as well as their predecessors and successors – if they know) had carried out the practice of policy making, as well as how decisions on new infrastructures have been taken in the past. See appendix 4 showing the research interview protocol. The theoretical lenses played a role in ascertaining the approach for the interviews and the kind of questions to ask. These are outlined in table 3.6.

Table 3.6: Sample questions based on theoretical perspectives

Theoretical perspectives	**Sample questions**
Techno-economics	Is project cost a major factor in infrastructure decisions? If so, how?
Social psychology	Have you ever been involved in decision making on a subject that is not of interest to you? What did you do?
Institutions	You work within an institution that has oversight functions on other institutions. How do you go about carrying out your oversight functions as a member of the parliament? How has this been done for the agencies in the energy sector, and electricity in particular?
Socio-technical transitions	We notice changes in laws and regulations. Can you explain how these changes occur within the framework of the parliament?

Duration of interview – The interviews were initially planned to last for an average of 45 minutes. However, most of the interviews lasted an average of 90 minutes. The minimum interview period recorded was 45 minutes while the maximum interview period recorded was 150 minutes. The major contributor was the fact that the interviews were not audio-recorded. The fact that interviews were not audio-recorded made the research participants more open to discuss freely. I only took notes of key points using pen and paper which were later transcribed.

Table 3.7: Details of selected research participants and interview date

Research Participants	Background/expertise	Date of interview
A	An experienced socio-political expert and economist. He was once a senior special adviser to the president on policy implementation. He has been working and consulting for the government for over 20 years.	13^{th} June 2015.
B	A senior politician with over 15 years' experience in the art of policy making. He was once a special assistant to an executive governor. He later moved to the Federal House of Representatives as a law maker where he chaired the house committee on treatise and policy for several years.	20^{th} June 2015.
C	A politician with over 20 years' experience in politics. He was a speaker of a state house of assembly for several years where he chaired several policy sessions at the state house of assembly.	18^{th} July 2015.
D	A senior technical expert in energy with over 20 years industry experience. He spent a large part of his working career with the Transmission Company of Nigeria (TCN) where he had technical responsibility for the smooth operation and maintenance of a section of the country's electricity grid network.	15^{th} August 2015.
E	A senior energy expert with more than 30 years' experience in the electrical power industry. He had responsibility for the general management and operations of one of the regions of the Transmission Company of Nigeria (TCN). Prior to that, he worked with the then National Electric Power Authority (NEPA) from early 1980s, and later the Power Holding Company of Nigeria (PHCN) where he worked at senior levels. He saw a large part of the policy and technical transitions of the Nigerian electrical power sector during his working career.	24^{th} August 2015.
F	An engineer with several years' experience working in the energy industry. He worked in Nigeria's biggest thermal power station for several years where he handled several roles.	8^{th} September 2015.
G	A communications expert with several years' experience in the energy industry. He was Head of Corporate Communications for one of Nigeria's biggest electrical distribution company for several years.	20^{th} September 2015.
H	An engineer with several years' experience in energy technology industry. He worked with some top Original Equipment Manufacturers involved in manufacturing and sales of power turbines and electrical network solutions. He has spent a large part of his working career in technology sales and marketing, interfacing with many of the end users and several stakeholders in the Nigerian energy sector.	30^{th} September

3.5 RESEARCH ANALYSIS METHOD

This section delves into the various data analysis methods and tools used for analysis of both qualitative and quantitative data collected in the course of the research.

3.5.1 Documentary data analysis

Archival analysis of most of the documents and archives from various institutions were used to obtain historical data that were used to analyse the Nigerian energy transitions. The data collected were used to analyse the historical evolution of energy demand using the connection and interplay of the trimetric parameters of: energy sources; energy technology drivers; and (social) practices of the people, in order to understand and explain the Nigerian historical energy transitions.

Archival analysis lends structure to research in a formal and systematic way (Hsieh 2005). This is the rationale for the choice of this analysis method. However, this was used in a critical way as it tends to ignore multiple meanings and context which is the focus of critical realism.

How were the documentary/archival records analysed?

Documentary and archival records were analysed through the theoretical lenses and some guiding questions as presented in table 2.4 of chapter 2. Data from these records were analysed and used to prepare a historical narrative on the various factors that influenced the evolution of energy infrastructure provisions in Nigeria from 1800 – 2015 as later detailed in chapter 4. I have also used literature and documentary archives (where necessary) to provide the background/context for chapters 5 and 6.

The following steps were followed in analysing archival documents/records (Lacerda 2012; National Archives 2017).

1. *Meeting the documents*: this process involves checking to ascertain if there are any special markings or figures on the documents which could tell us something in connection with the subject under study. Circle or highlight those markings
2. *Observing the parts:* this entails finding out who wrote the documents and for what purpose. When was the record produced and archived? Are those dates useful in analysing times of energy transition and how society develops over time?
3. *Trying to make sense of the documents:* this stage entails trying to obtain the main ideas of the documents. Why was the document written? Are there useful aspects that support my research and can be used as evidence?
4. *Use the documents as historical evidence:* this stage helps in asking questions that can help provide answers to validate the use of those documents as evidence. For example, where can I find more information about a particular event referenced in the document? Where can I find more information about the person who wrote the document? Are there empirical evidences that are aftermaths of the things observed in the documents?

Indeed, the aforementioned process guided the data analysis that addressed the first sub-question.

3.5.2 Qualitative data analysis – thematic data analysis

Qualitative data collected during research can be analysed in different ways using one or more of the various methods such as: thematic analysis, descriptive approach, or more in-depth methods. Thematic data analysis is used for the analysis of qualitative data collected in the course of this research.

Thematic data analysis looks across all the generated data to see or identify the common issues that occur (Fereday & Muir-Cochrane 2006). It seeks to find the main theme(s) that summarizes all of the views of the data collected. This method is the most commonly used for descriptive qualitative projects and research. The following were steps used in the thematic data analysis of this research.

- *Collect all data.* – Data was collected with the use of pen and paper (scribbled notes), which was the method acceptable by all of the research participants
- *Transcribe conversations in order to start to see and list the patterns of experiences of the participants*. - This was done mainly by paraphrasing common ideas. I ensured the use of direct quotes was omitted due to the high profile of the research participants. This is also to ensure confidentiality and anonymity which is quite crucial considering the cultural context of Nigeria.
- *Identify data* that relates to the already classified patterns.
- *Combine and catalogue related patterns into sub-themes* - Themes are derived from patterns such as recurring activities, meanings, and conversational topics (Singh 2006). They are identified by bringing together experiences, components or fragments of ideas which are meaningless when viewed alone.
- Build a valid argument for choosing the themes by studying related literatures.

The initial plan was to use the Nvivo software for coding and thematic data analysis in order to find out the recurring words and themes. However, the use of pens was used for coding (see appendix 8). . Aside the problems encountered while loading the Nvivo software on my computer (such as difficulty in installation, and eventual system crash), I opted for the pen and paper option for the following reasons:

1. Nvivo does not recognise or process Microsoft-Word easily. It insists on rich text format. This means all transcripts have to be formatted to rich text format for Nvivo to recognize it.
2. Another challenge of some software packages is the issue of over coding. I wanted to ensure the core messages that were conveyed during the interviews

were not lost due to over coding. With the use of software packages, the researcher could end up with too many themes and categories that could make the process of categorizing the data unmanageable (Welsh 2012).

The use of software also brings the limitation of only seeing a section of the material on the screen which poses the difficulty of fully visualizing and conceptualizing the whole data (Mclafferty 2006).

<u>How were the themes generated?</u>

The themes from the interviews were generated in two ways:

1. By highlighting and noting down some recurring notions from the interviewees during the interviews (see an example in appendix 9).
2. By pen and paper coding of the interview notes developed after each interview to identify common patterns and themes (see an example in appendix 8).

Indeed, the themes generated were a result of the synchrony between the noted recurring notions made by the interviewees during each interview and those discovered in the course of the pen and paper coding of the interview notes. In appendix 7, extracts from the interview notes from different interviews were presented. Appendix 9 shows some examples of recurring themes and statements during the interviews. The interview protocol is presented in appendix 4, while the coding frame for the interviews is presented in appendix 10.

With respect to the theoretical lenses, the coding process was not directly influenced by the theoretical lenses. What really happened was that the coding went on and the themes generated were now compared to see what theoretical lenses they supported. In essence, the interview protocol were influenced by the theoretical lenses, but not the coding process.

3.5.3. Assessing validity and reliability

Reliability measures the consistency of data over time. Validity tests the degree of truthfulness of the source of data presented in a research. A good and reliable research must have three essential qualities:

1. It has to be relevant
2. It has to be verifiable
3. It has to be unbiased.

In this research, relevance was measured by ensuring that the evidence collected were up-to-date and that they directly explain the subject matter under study. Evidence from archival records, trade journals, academic literature, policy documents and interviews were collected to determine the aftermath of events and happenings over a period of time in relation to the subject under study. The evidence collected gave ideas about the various contexts that have impacted on energy infrastructure supply in Nigeria over time.

Since evidence are verifiable facts, testimonies, expert witnesses or pieces of statistics; this research has focussed on evidence that are verifiable through archival documents and interviews. If the same sets of documents and a similar sample frame is used to conduct this research, (following the arguments) the researcher should be able to reach the same set of conclusions (Creswell 2003).

Biases are preconceived notions or opinions that are not based on actual experience or reason. The issue of bias in this research was addressed by ensuring that the findings and conclusions were data driven. However, there is also a limitation since the research was done by an individual, to limit the possibility of bias, all of the findings of this research have been peer-reviewed by others and have been published in highly ranked academic journals. Throughout this research, I have kept the bias limitation in mind and further studies would either support or demonstrate where bias may have appeared. Indeed, I have considered this point from the very start of this research (Podsakoff et al. 2003).

Within a mixed methods research context, the importance of triangulation is emphasized (Yeasmin & Rahman.K.F 2012). Since this research used mixed methods, I have focused more on triangulation. Validation is a positivist notion. Critical realists acknowledge that subjectivity (plus bias) is inevitable. Indeed, in this study validation does not mean that the same thing is found, but together the data can point towards the rest layer which may be less influenced by real world experience.

3.6 ETHICAL CONSIDERATIONS

Before the commencement of data collection, the Anglia Ruskin University Faculty of Science and Technology (ARU-FST) research ethics committee received the various documents required for research ethics approval. Some of the documents submitted to the faculty research degree ethics committee for research ethics approval included:

- Research participant information sheet (see appendix 1)
- Research participant consent form (see appendix 2).
- Research risk assessment document (see appendix 3).

Data collection only commenced after formal ethics approval (in writing) of the research by the faculty research ethics committee (see appendix 6).

Considering the high profile of the research participants, it was inherent that some clear ethical guidelines be followed in order to ensure that both the researcher and the research participants are protected. This research focussed on the following aspects of ethics in research (Resnik 2014):

Principle of voluntary participation

The principle of voluntary participation requires and ensures that the participants in the research are not coerced to do so. In order to ensure this, the research participants were recruited by formally writing them (via recommendation from their friends and an SMS). The purpose and aims of the interviews were clearly stated. Their participation in the research was based on their voluntary acceptance.

Principle of informed consent

The principle of informed consent requires that all prospective participants in the research are duly informed of the risks and procedures involved in the research and must give their consent to participate. In this research study, aside stating the aims and objectives - as outlined in the Participant Information Sheet (PIS) - The Participant Consent Form (PCF) was presented to the research participant before the start of each interview for their signature. This was done in order to ensure the research participants do not feel coerced to participate in the research, thus, ensuring that their participation is voluntary.

Risk of harm

The procedures adopted in the conduct of this research were aimed at ensuring the safety of both the researcher and the research participants. As such, the choices of interview venue, as well as other safety procedures as laid down by the Anglia Ruskin ethics committee were strictly adhered to.

Principle of confidentiality and anonymity.

Considering the profile of the target participants, concrete steps were taken to ensure the confidentiality of the information gathered from each of the research participants. I ensured that the data gathered were not made available to anyone who is not directly involved in the research. Another way of ensuring confidentiality was avoiding the use of recording during interviews as this is something very sensitive to the class of research participants I had to deal with. The notes developed from each interview were typed and encrypted. Other necessary steps were also taken to ensure the research participants remain anonymous throughout the study.

3.7. SUMMARY: LINKING DATA SOURCES AND RESEARCH PHILOSOPHY

The three layers of critical realism (i.e., the actual; the real; and the empirical) points to three epistemological layers. The 'real' cannot be seen. We can only speculate what happens in the 'real' based on activities/events that happens in the 'actual' and the observations in the 'empirical' layer. Thus, the real, actual and empirical layers are epistemological layers used within critical realism to gain knowledge of reality.

The layers of critical realism are artificial constructions that allow one to talk about what one finds/observe (in the data). They represent reality in some way. The layers also provide an avenue to discuss my influence (as a researcher) on the results.

Since the 'actual' are events that results from the real layer, documents reporting (historical) actions, decisions and events were used. It can be argued that these documents were based on the writer's perspective and may not reflect the true and full picture of the 'actual'. However, documents and archives used were what were available in ascertaining the 'actual'.

The 'real' layer entails the underlying mechanisms and dynamics which are not observable. The only way of ascertaining the 'real' is by enquiring from the actors who engage in activities that impact on those underlying dynamics. Hence, the choice of interviews with policy makers and those responsible for the electrical energy infrastructure provisions and governance.

The ‘empirical’ are the observable phenomena which are often results of the events, actions and dynamics that proceed from the real and the actual layers. Hence, the empirical was sought through documents, archives and interviews.

Part III: Results and analysis.

Chapter 4 ENERGY TRANSITIONS IN NIGERIA: THE EVOLUTION OF ENERGY INFRASTRUCTURE PROVISION (1800 – 2015).

This chapter, in answering the central research question, focused on addressing the first sub-aim which is: “how has the electricity supply infrastructure evolved over time and what contexts have influenced this evolution?” Table 4.1 presents a summary of the sub-question being addressed, the guiding theories and the guiding questions which serve as point of departure in addressing the chapter aim.

Table 4.1: Summary of chapter aim and guiding theories

Sub-question (chapter aim)	**Guiding theories**	**Guiding question (point of departure).**
How has electricity supply infrastructure evolved over time and what contexts have influenced this evolution?	Social practices	What were the social practices of the people and how has it impacted on energy supply infrastructure?
	Institutions	How has institutional interventions on energy infrastructure emerged?
	Socio-technical transitions	What led to the changes in energy resource use? Who were responsible?

4.1 INTRODUCTION

Energy transition involves “long term structural changes in energy systems” (Davidsson 2014b, Pg 2) (Geels 2010). Many developed countries have gone through some energy transition, while some are still experiencing some sort of transition (O’Connor & Cleveland 2014; Davidsson 2014b). All countries undergo transitions as a result of economic and societal change (Verbong & Geels 2007; Geels 2006; Shove et al. 2015). Learning from the experiences of the other countries does not necessarily mean they have to take the same steps as some developed countries did in the past, but they may have to learn to understand the vast processes that are involved in a transition (Bridges 2000). However, how much knowledge do we have on the historical energy transitions across most developing countries? How many records and research outputs really point to the factors that influenced such transitions? How many studies have been done on the influences of policy practices on energy transitions from a developing economy perspective? These are questions that the current bodies of research have not been able to satisfactorily answer. Addressing these questions is important as a lack of knowledge of a country's energy histories poses challenges in policy governance that can pave the way towards a more sustainable energy future (Edomah 2016).

The case study presented in this chapter focused on the Nigerian energy transition. There is currently no known study on the Nigerian historical energy transition (O'Connor 2010). Most transition studies have focused on energy resources (Diji 2013; World Economic Forum 2013), energy consumption (Onakoya et al. 2013), energy production (Dzioubinski & Chipman 1999), energy poverty, and energy access (OECD/IEA 2010). Bridge argues that there is a clear need for a more focused study on the geographies of energy transitions in terms of space and place (Bridge et al. 2013). This is important as the aggregation of knowledge and experiences of the transition histories of different geographies will help different stakeholders in learning from past experiences and ensuring avoidable mistakes are not repeated.

Indeed, I have been unable to find academic research on the Nigerian historical energy transition. This is in spite of the importance of understanding historical transitions for enabling new sustainability transitions, as argued by Falcone (2014). It is in this context that this chapter explores the past Nigerian energy infrastructure transition, with a focus on the historical development of energy demand and energy infrastructure provisions since 1800. This chapter specifically aims to highlight some of the dynamics around the provision of such infrastructure, by answering the question:

- *How has Nigerian electricity supply infrastructure evolved over time and what contexts have influenced this evolution?*

In exploring this research question, this chapter considers five different energy eras. The five eras can be considered as socio-technical eras in Nigeria. Using the history of energy supply changes in Nigeria, broad and significant technology transitions were considered as the start of a new era.

Indeed, all five theoretical lenses were not used in an equal manner in describing the various eras. However, they formed the basis for explanation of the various events within each era that shaped energy infrastructure supply. These eras are characterized by different historical happenings in the life of Nigeria(ns). The core of this chapter is structured around these eras, with particular attention given to how infrastructure has evolved alongside societal changes and the role of changing institutions within that (Chappin 2011).

Since energy use co-evolved with advances in technology, the Nigerian energy transition is broken down into different eras of energy use according to the technologies that were being introduced and used at that time, as well as the different primary resources which were being exploited. Typically, those primary resources were successively more energy-dense types of energy resources, e.g., coal, and crude oil. Energy density is essentially the amount of energy per unit volume (Demirel 2012). The Nigerian energy eras are:

- *Pre-industrial (agricultural) era* – up to mid-1800s.
- *Early industrial (advanced metallurgy) era* – late 1800s.
- *Industrial (steam engines) era* – early to mid-1900s.
- *Late industrial (dynamo, internal combustion engines) era* - mid to late 1900s.

- *Information (microprocessor) era* – early 2000s onwards.

In providing an overview of these eras (section 4.3), the intention is not to provide an exhaustive history of energy use and technology, but to instead lay the foundation for thinking about the business challenges in developing primary energy resources, as part of enabling a deeper understanding of how energy infrastructure evolved over time (Orlando 2014). Within this overview of the energy eras, I relate those same eras to the changes in Nigeria's political decision-making institutions, so as to emphasize the historically dominant influence of the British and other foreign envoys in Nigeria. Indeed, and as I will go on to discuss, the development of infrastructure that led to changes in consumption patterns of Nigerian locals (and a corresponding increase in demand for various energy sources) were a result of the various exchanges brought about by the colonialists who tried to continue the lifestyles they were already used to. I finish with a discussion (section 4.4) and the conclusion (Section 4.5) which considers the cross-cutting themes.

4.2. MATERIALS AND METHODS

This section presents the tools used for data collection and analysis. the rationale behind the choice of documents and the data analysis tools used.

4.2.1. Data collection

This study employed the use of exploratory archival (documentary) research tools by exploring archival documents, official data and statistics on the different aspects of the life and history of Nigeria in connection with trade, traditional energy use, culture and norms. Documents and archives from several sources were used in data collection and analysis to have a better understanding of how the historical events of the time influenced and affected energy infrastructure provisions.

Document sources

Quantitative and qualitative data were collected from existing literature, documents and archives of various institutions using documentary literature research tools. A document is a written text, produced by individuals and groups in the course of their work, and are geared exclusively for their immediate practical needs (Scott 2006). They are written based on particular assumptions and with a clear purpose. In documentary study, there are two types of documents used:

- *Primary documents* - this refers to eye-witness accounts produced by people who experienced the event or behaviour under study.
- *Secondary documents* – this refers to documentary accounts produced by people who were not eye-witnesses of the event or behaviour under study, but who rather received eye-witness account to compile the documents, or have read eye-witness accounts (Johnston 2014).

Table 4.2 shows a summary of the different sources of documents used. It should be noted that I was only allowed to view and read some of the archival documents at the government offices. I was not allowed to make copies of some of the records.

Table 4.2. The various sources of documents used for documentary research.

Archival sources
Diaries, letters, memos, and memoirs contained in the detailed account of Francis Jackel covered in the following volumes of the history of the Nigerian Railway: Francis Jackel (1997) “History of the Nigerian Railway: Opening the nation to sea, air, and road transportation”. Vol.1. Spectrum Publishers. (Out of print). Francis Jackel (1997) “History of the Nigerian Railway: Network and infrastructure”. Vol.2. Spectrum Publishers. (Out of print). Francis Jackel (1997) “History of the Nigerian Railway: Organization, structure, and related matters”. Vol.3. Spectrum Publishers. (Out of print).\ Some historical policy documents
Organizational reports of the United States International Energy Agency (IEA) and the Energy Information Administration (EIA) as contained in the following selected documents: IEA, 2012. Energy Technology Perspectives 2012 Pathways to a Clean Energy System. *Internationaal Energy Agency*. IEA, 2011. IEA analysis of fossil-fuel subsidies. *World Energy Outlook*, IEA, 2014. Speical Report: World Energy Investment Outlook. *International Energy Agency*. EIA, 2015. Country Analysis Brief: Nigeria. *US Energy Information Administration*.

Data used for the analysis of the events from colonial Nigeria (and a little from pre-colonial Nigeria) were sourced from the archives of the Nigerian Railway Corporation (NRC). The NRC is the only organization in Nigeria still in existence today that has a history pre-1900. Also, most events and happenings – particularly trade, movements of goods and agricultural products, initial provision of electrical infrastructure, etc. – were largely made possible by the provision of rail infrastructure. The planning of most parts of the rail transport infrastructure was highly connected with other infrastructural developmental plans, such as; electricity, ports and harbours, airports, industrialization, and trade activities. The roles of these various aspects are highlighted in the description of the events of each energy era and how they impacted on increased demand for energy. It should be noted that NRC have the largest historical archives in

Nigeria, and other institutions do not have the kind of data as contained in the NRC archives.

The other documentary sources from the International Energy Agency (IEA), Energy Information Administration (EIA) and the World Energy Council (WEC) only have useful evidence and records of Nigeria post-independence (1960 onwards). These agencies have, in their archives, records and data of the Nigerian energy resources, consumption, and production, covering 1970s to present day. As such, these do not provide a reliable means of getting a true historical picture of the Nigerian energy situation pre-1960.

Why use documents?

Documents and archival records are among the few reliable sources of data which covers past events that dates back to centuries. Interviews have their own limitations as the participants can only narrate his experience (or what he has been told by those he met in the preceding generation). Archival records provided documentary proofs of how people lived in the past, how they traded, and what technological interventions aided the kind of work they did, etc.

It is noteworthy that in many existing transition studies, one can easily notice the extensive use of quantitative (and qualitative) data from published literatures, and particularly archives of some agencies, used in collecting data and making meaningful analyses which serves as pointers, suggesting various constitutive elements of the energy history under study. This research does not only focus on collecting archival records, but also tries to validate and enrich the data through collection of qualitative data via personal interviews from people who have also been involved in the energy history (in chapter 5 and 6). See appendix 6 for some extracts of documents used for data collection.

4.2.2. Data analysis

Archival content analysis of the documents and archives from various institutions were used to obtain historical data that were used to analyze the Nigerian energy transitions. The data collected were used to analyze the historical evolution of energy demand using the connection and interplay of the trimetric parameters of: energy sources; energy technology drivers; and (social) practices of the people, in order to understand and explain the Nigerian historical energy transitions. Indeed, these three parameters as highlighted were used to frame the findings from documents to better explain the historical drivers of energy infrastructure supply. These parameters were informed by the theoretical lenses In the following manner:

- *Energy technology drivers* (informed by technology pathways) and shaped by techno-economic theory.
- *Energy sources* (informed by energy resource options) and shaped by institutional theory on energy governance
- *Social practices* (informed by public values for energy systems) and shaped by social practice and social psychology theory.

The changes that occur as a result of the interaction between the three aforementioned parameters results to the various socio-technical eras as presented in section 4.3.

Documentary and archival records were analyzed through the theoretical lenses already presented in chapter 2 (see table 2.4). Data from these records were analyzed (as detailed in chapter 3) and used to prepare a historical narrative on the various factors that influenced the evolution of energy infrastructure provisions in Nigeria from 1800 – 2015. Indeed, with respect to critical realism, this analysis aimed at finding out the historical events and activities that have happened in the past which forms part of the empirical (evidences).

In addressing these aforementioned points, the role of varied influences/drivers of energy systems change within each era was also considered. This provided the basis for a narrative on the resource and political influences on Nigeria's energy supply infrastructure.

4.3. NIGERIA'S ENERGY SUPPLY INFRASTRUCTURE: RESOURCE AND (POLITICAL) INFLUENCES

This section presents the various energy eras for Nigeria with respect to the trimetric parameters of energy demand and use, technology driving demand for energy, and the primary energy resources used in satisfying energy demand within each era. It also discusses the role of institutions, within each era, in effecting changes in energy systems and use. The eras identified are intentionally artificial and have been employed to emphasize salient features of different time periods across the Nigerian energy transition.

4.3.1. Pre-industrial (agricultural) era – up to mid-1800s.

The first energy era in Nigeria was the pre-industrial era, which spans several centuries from 1500 up to mid-1800s. In this era, the primary energy resource used was organized (peasant) agriculture. This resource was effective for the kind of work and society that was needed at that point in time, which mostly related to manual work and walking. Manual work was what was needed to produce agricultural products and for transporting goods to markets.

4.3.1.1. *Agriculture as the main driver of energy demand*.

Agriculture was the mainstay of the economy of most families, communities and empires during this era (Inikori 2013). The cultivation of food crops for human consumption was the main agricultural practice. The emphasis was on peasant farming. Families had farmlands where they could cultivate and produce different food crops for consumption throughout the farming year, as well as having enough to trade to earn resources to take care of their other needs. Through this period, agricultural practices evolved and farmers were able to learn from their experience different innovative ways of tilling and cultivating the land to obtain greater yields. This led to the use of semi-mechanized farm tools such as hoes, local ploughs, wheel barrows, and other innovative forms of farm implements.

Through agriculture, other practices evolved, such as those involving arts and crafts. The use of dishes made from wood carvings used exclusively by the kings and the ruling class within some cultures in southern Nigeria dates back centuries (Green 2013). Furniture was made from wood obtained from trees, while cooking and heating requirements were from agricultural by-products. Some cultural festivals considerably depended on agriculture, such as celebrating the new harvest season, which was – and is still – common in parts of southern Nigeria.

Energy (calories) from food was required for both for manual labour and draft animal labour. Energy required for heating and cooking was from wood and agricultural by-products. Oils derived from food and other agricultural by-products were used for oil lamps to serve lighting purposes. The essential factors that influenced the transition to the next energy era during this period were trade and European exploration of Africa.

4.3.1.2. ***European exploration, trade and energy demand*.**

Early contact between Nigeria and the Europeans dates back to 1472 when the Portuguese bought pepper and ivory from Benin City, within the great Benin Empire in Nigeria. Lagos was discovered in the same year and named by Lancelot de Freitas, the caravel captain, as Lagos de Curamo, finally called Lagos which displaced the Yoruba name, *Eko*, years later resuscitated by the Holiday Inn Group. This happened during the time of the navigator, Prince Henry, grandson of John O. Gaunt, Duke of Lancaster (Francis Jackel 1997b).

Trade had been happening since the 15th century and had continued during those periods – particularly through the desert into northern Nigeria with cities like Kano, Katsina and Zaria – as recorded in the book of Leo Africamus on *West African Empires* published in 1526. Most trade continued across the desert until the coast became better known in the 15th century, when contact was further established with Fernando Po and Sao Tome (two islands on the coast of West Africa), so that Nigeria became tapped on its northern and southern limits. Brazil specifically established trade in the 17th century in Badagry area of Lagos. The eastern coastline of Nigeria had been dubbed '*Oil Rivers*' as at 1831 (Francis Jackel 1997b).

Alongside trade came knowledge transfer of new techniques and practices, which helped shape early aspects of Nigeria's energy transition. Agricultural activities, arts, and crafts done manually with limited use of tools (particularly in the Benin kingdom) promoted trade relations with foreign European traders which led to the exchange of ideas and the embrace of better technology in achieving the same work and practices with limited amount of energy. Thus, contact with Europeans through trade led to the next transition in energy use, energy consumption pattern, and energy demand due to new practices embraced from the trade partners over time which were more energy intensive. All of the aforementioned were pointers to an energy intensive future fostered by trade, investment, and cultural exchanges (Sparti 2003).

<u>4.3.1.3.</u> *Influences and drivers of energy infrastructure supply in the pre-industrial (agricultural) era.*

This era, which was characterized more by agricultural practices and interventions, saw the extensive use of traditional biomass (mostly by-products of agriculture, such as wood) as the major source of energy. The following were key drivers of energy infrastructure supply in this era:

1. Institutional interventions
2. Economic considerations
3. Energy resource options
4. Social practices and public values

Institutional interventions

There were two pre-dominant decision-making institutions during this era:

1. Families
2. Traditional institutions (rulers)

Families made decisions based on their needs and available resources. Most families used oils from agricultural by-products for their lamps for lighting needs (Okeke 2013). Peasant agriculture was the major source of food for most families. Families took decisions in matters concerning their domestic energy needs which had a great impact on the increased energy needs in the forms of food and other agricultural by-products needed for cooking and other (domestic) applications. The impact of the aggregation of the individual family needs led to the increased demand for energy, thus, increasing the need for improved agricultural by-products and the need for better innovation in meeting the new forms of energy demand.

Traditional rulers played a very instrumental role as much of the trade activities were the results of decisions taken by either the traditional ruler(s), or the traditional ruler(s) together with his council of chiefs (as was the case in some parts of southwest Nigeria) (Okeke 2013). Trade activities with foreign envoys and partners by some kingdoms and communities – such as the Benin kingdom, Badagry area in Lagos – led to the exchange of ideas and practices that later became energy intensive (Alabi 2006). Trade activities improved during this era – particularly arts and craft, as well as agricultural produce – which encouraged the increased cultivation of agricultural cash crops for domestic consumption and export (Keulder 2000).

Decisions in (nuclear and extended) family circles, as well as decisions by the traditional rulers and the council of chiefs were the main institutional drivers of the changes that occurred during this era in relation with energy use and demand.

<u>Economic considerations</u>

During this era, increased agricultural output was considered synonymous to economic prosperity. Growth in agricultural productivity meant increased potential for more trade leading to increased income. Since agriculture was the mainstay of the economy during this era, increased productivity helped in sustaining families, maintaining communities and supporting traditional festivals, such as: the harvest festivals

<u>Energy resource options</u>

During this era, the available energy resource was from food calories. Decisions on energy resource use depended on families and local communities. The availability of food calories meant that most practices performed were based on manual labour and draft animal labour. This was very demanding as there was need other energy resource options that could help reduce the use of manual labour in achieving different practices.

<u>Social practices and public values</u>

During this era, energy from food calories was perceived as a common and societal good. The availability of this energy source provided the basis for several practices to be implemented in different sort of ways, such as commuting and trade. Trade was a very important practice that led to more demand for energy. Trade activities improved and many Nigerian locals saw the need to increase their export produce that would be sold to their trade partners. It is the perceived value (a means of livelihood) and the trade practices that led to demand for new forms of energy to help increase production output of food produce, arts and crafts for export.

4.3.2. Early industrial (metallurgical) era – mid to late 1800s.

During this era, the continued use of wood for heating and cooking was still very pre-dominant. There were really no technologies used to produce energy. The available technologies were still leveraging the older forms of energy which had also been used in the pre-industrial era (food calories). However, the extensive use of metallurgical interventions added some new dynamics to energy use during this era. Metallurgy is the technology of metals which involves the use of metals for manufacturing and consumption purposes (European Commission 2014; P. R. Jochens 1980). The use of metallurgy does not mean that metallurgy was invented at this point, neither does it mean that metallurgy had not been in existence before then. It only highlights how knowledge of metallurgy helped in extensively mechanizing many industrial processes, not just in agriculture but also in the production of machine and agricultural tools, which helped the local small industries, particularly for transportation needs, such as wheel barrows, bicycles, and other mechanisms used for transportation with draft animals. The following are key highlights of the role metallurgical interventions played in Nigeria's energy transition during this era (P. R. Jochens 1980):

- It led to mechanization of some agricultural processes, which aided the further production of cash crops for export (as noted in parts of northern Nigeria).
- It was very instrumental in the initial survey and development of the railway transport system, which started during this era.
- It played a role in the initial study, survey and justification for future ports, terminals, and harbour infrastructure.
- Knowledge of metallurgy was instrumental to the provision of the first electricity generation infrastructure (mainly for lighting) during this era.

A key development during this period was the provision of transportation infrastructure. Transportation is simply the movement of people and goods through some defined modes (such as rail, road, air, or sea) from one place to another (Orlando 2014). The extensive use of metallurgical interventions during this era prompted the need for an extensive study on how various transportation infrastructure can be developed to open up the country to socio-economic and political development. This section delves into the pre-historical happenings on how decisions on the various transportation infrastructure started.

<u>4.3.2.1.</u> *Railway transportation development in Nigeria.*

The Nigerian railway was initially pioneered by some private interests, and later taken over by the then Colonial Government as government railway with the main aim of opening up the country and easing the transportation of bulk goods from the hinterlands to the coastal seaports for export, and vice versa. The following were major milestones in the development of rail transportation during this era (Francis Jackel 1997b):

1879 – 1892.	Several applications for concessions were received by the Colonial Government from private interests to construct rail networks.
1879 – 1892.	An initial survey was conducted by Mr. William Shefford, which revealed great potential of rail transport networks for trade in the country.
1895.	The then Secretary of State for Colonies, Mr. Chamberlain, gave approval for the construction of 32km of 1067mm gauge rail line from Iddo (Lagos) to Otta (Ogun State).
1898	The construction of the first rail line in Nigeria commenced. A 193km rail line from Lagos to Ibadan. It was completed in 1901.

The later part of this era saw the extensive provision of rail tracks (particularly for the first railway line) for rail transportations.

4.3.2.2. *Ports, harbours, and terminals development*

Activities during this era provided the basis for the future development of ports, harbours, and terminals in Nigeria. As of 1863, 99 ships called on the Nigerian coast, 58% of which were British. By 1893, the number had grown to 446, of which 53% flew the British ensign (Figure 4.1). Nigeria's economic growth was highly influenced by trading of oil palm produce. As of 1900, the total trade had reached £4.0m, which is worth about £470m in current estimates (Francis Jackel 1997b). Increased trade activities led to the need for ports and harbour infrastructure.

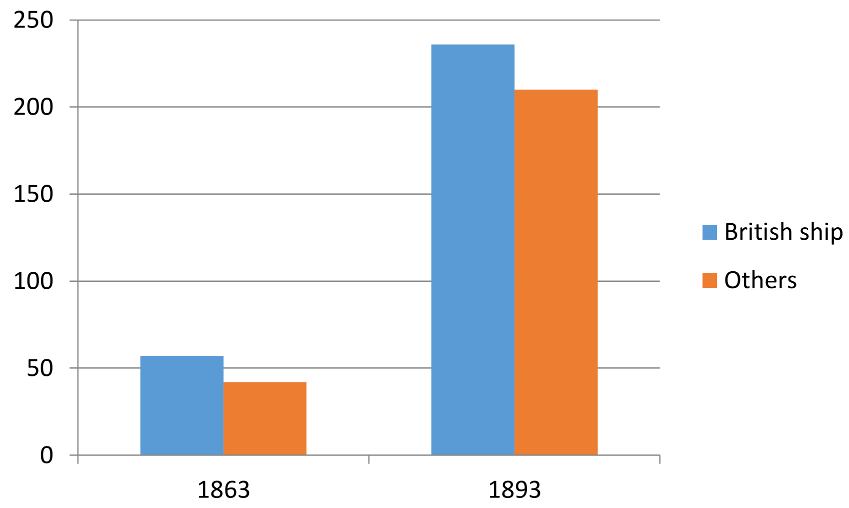

Figure 4.1 Number of ships that called at the Nigerian coast.

4.3.2.3. *The first Nigerian electrical power station.*

The first Nigerian electrical power plant was built at the cost of £6k (~£702k using current estimates) in Lagos Marina in 1896. As early as 1898, the streets of the Lagos Marina were lit between 6pm and 11pm by series connection. The power plant was built by the Public Works Department (PWD), this same site was taken much later by the Electricity Commission of Nigeria (ECN) as its national headquarter building. The plant comprised of two 30KW, 1000V, 80-cycle, single phase supply. The power plant was primarily used for lighting purpose. The government house was first lit, followed by the colonial hospital. As of 1899, most streets on the Lagos Island were lit by glow lamps with maximum demand reaching 24KW. A third unit was installed in 1902 due to increasing demand for electricity for lighting, which was fast replacing the use of traditional lamps with oil from food sources. By 1909, installed capacity had reached 120KW, with registered energy demand already reaching 65KW (Francis Jackel 1997b).

Through installation of some underground 10,000 yard-long High Tension (HT) cables that fed 31 transformers (of which the largest was 5KVA capacity), electricity reached Iddo and Ebute-metta axis of Lagos. In 1901, one of the colonial masters, Lord Lugard, undertook a similar project for the Niger Company and illuminated government house in Zungeru (a small city in North-Central Nigeria). The development of electricity infrastructure was very slow since most of the activities at that time were agriculture, which did not support enough industries to justify the development and provision of an economic power supply. When industries were projected, there were no funds available. The only notable exceptions were the Lagos railway workshops at Iddo, and later at Ebute-metta, which were largely responsible for the replacement of the Lagos steam plants by diesel engines after 1910 in the new distribution of 2-phase, 40 cycles. However, in 1914, the First World War put an end to further development of this power plant, as it was necessary to cannibalize some power plants to provide spares to keep the others working. By 1918, the street lights had to be turned off due to increased energy demand and insufficient supply.

This era heralded the pre-history of many infrastructural provisions in the next energy era which led to a sharp increase in demand for energy. The initial provision of the first electrical power plant, the surveys that led to the extensive provision of rail transport infrastructure, increased trade activities that led to the development of the ports, harbours, and terminals, as well as improved mechanization of agricultural practices increased the pressure for other forms of primary energy resources to meet the growing energy demand.

4.3.2.4. *Influences and drivers of energy infrastructure supply in the early industrial (metallurgical) era.*

This era saw the extensive use of metallurgical interventions in energy use. The key drivers of energy infrastructure supply during this era were:

1. Institutional interventions
2. Technological interventions
3. Economic considerations

Institutional interventions

The institutional decision-making platforms that were vital in shaping this stage of the Nigerian energy transition were:

- Colonial institutions
- Traditional institutions (traditional rulers)

Decisions during this era were done predominantly by the British colonialists who at that point already had their foot in Nigeria. The regional colonial governors were responsible for decision-making for the northern, eastern, western, and Lagos regions. At that time, the British colonialists started making necessary plans to set up institutions targeted at providing different infrastructural facilities to open up the nation as well as sourcing the necessary resources. This resulted to the establishment of two pivotal institutions:

1. The Public Works Department (PWD)
2. The Nigerian Railway Corporation (NRC)

The PWD was established to plan and develop several infrastructural facilities in Nigeria (roads, electricity, ports and harbours, etc.). The PWD intervened in the establishment of the first electrical power plant in Lagos, which served lighting purposes. This intervention led to increased demand for electricity since this provision led to increased perceived public value for electricity.

The NRC intervened in the planning, surveys and provision of rail transport infrastructure. The NRC was formed to open up the nation to rail transportation to ease the movement of agricultural products from the hinterlands to the coastal cities for easy export. In 1896, construction started on the first rail line in Nigeria linking Lagos to Ibadan.

Traditional rulers continued in their work of governance at the local community level (Deji 2013). However, the coming of the British colonialists into the decision-making scene impacted on the kind and manner of decisions taken (Keulder 2000). This era saw a closer union and more cordial working relationship between the British colonialists and the local traditional rulers in the decision-making process. This cooperation, however, led to some ugly situations in mutual trade such as the slave trade.

Technological interventions

Changes in energy systems during this era were also influenced by technological interventions. Two forms of technological interventions were evident during this era:

1. Metallurgical technology
2. Electrical technology

The extensive use of metallurgy during this era aided the planning and development of several infrastructure. Metallurgical interventions aided the production of farm tools to aid agricultural practices and increase crop production. The provision of the first railway line in Nigeria was also aided by the extensive deployment of metallurgical interventions during this era. These interventions aided the provision of mass transportation infrastructure (such as the railway line).

Electrical technology interventions aided the provision of the first electrical power plant in Nigeria which was used mainly for lighting applications. However, this initial provision paved the way for future electrical technology interventions to cater for future electrical energy needs due to increased demand for other applications, such as, electricity needs for the workshops of the Nigeria Railway Corporation.

Economic consideration

During this era, economic considerations were centred on increased trade volume, growth in income and productivity. Policies of the colonial administration at the time were centred on providing infrastructure aimed at economic development that supports trade. These were part of the considerations for the planning and eventual provision of the first railway line and electricity infrastructure in Nigeria.

4.3.3. Industrial era – early to mid-1900s.

This era saw the use of steam engines in manufacturing to produce mechanical work. The discovery of coal in 1909, led to the increasing use of coal for heating water to run steam engines. Consequently, this era saw the use of dynamos and electric generators in Nigeria. The use of coal for electricity generation was introduced, with the first coal fired power plant in Nigeria commissioned in 1923 in Lagos. As such, coal was not only used to run a steam engine, but also used in electricity generation.

In this era, there were mechanical needs for manufacturing which evolved with more diverse types of manufactured goods; and mass transportation with the introduction of trains and rail transport systems in Nigeria.

During this era, steam engines were the main technology driver of energy demand. The gradual embrace and extensive use of steam engines aided the following:

- The provision of the first few electrical power plants, which were used predominantly for lighting within the first two decades of this era.
- The use of steam engines in industrial applications and manufacturing - particularly in agro-food processing – to do mechanical work.

This era saw the initial steps towards the discovery and development of primary energy resources in Nigeria (particularly coal) and their impact on increased energy demand (Raji & Abejide 2014). The following sections highlights the various aspects of steps taken in development of primary energy resources.

4.3.3.1. *Coal development, mining activities, and energy demand.*

Coal was discovered in Nigeria in 1909 in Enugu, eastern Nigeria. It is the oldest commercial fuel in Nigeria with early production dating back to 1916, when 24.5k tonnes of coal was produced. This era saw the increased use of coal for mass (railway) transportation, increased electricity generation, and other industrial application of coal. Figure 4.2 highlights the growth of coal as the primary energy resource during this era. Despite this growth, between 1944 and 1948, Nigeria started experiencing a decline in the use of coal for electricity generation. This was due to the reduced mining activities impacted by the Second World War, as well as the mini-discoveries of crude oil which led to the commercial discovery of oil in Nigeria in 1956.

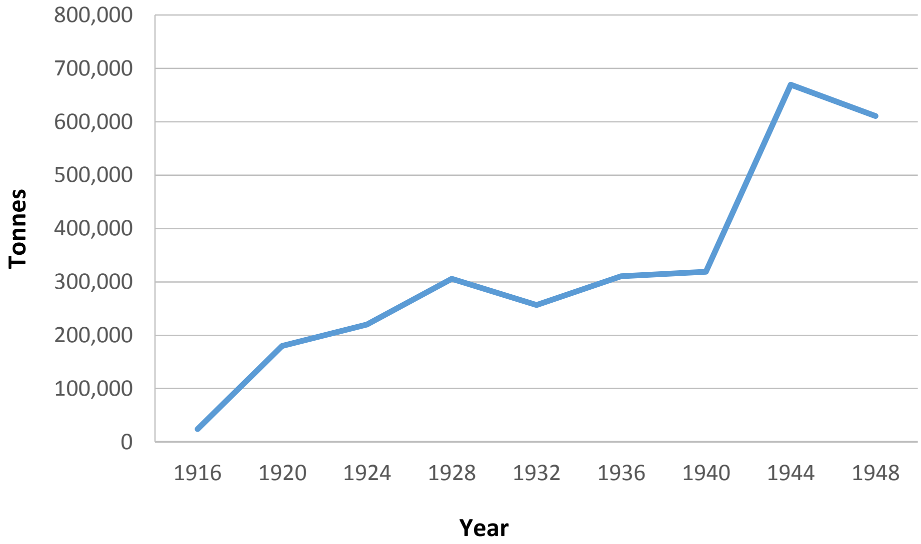

Figure 4.2: Coal productions in Nigeria over 1916 – 1948 (Data source: Nigerian federal ministry of mines, 2010).

During this era, coal was used extensively for thermal and mechanical needs in manufacturing, particularly in fabricating machine tools, metal machines, etc.

<u>4.3.3.2.</u> ***Further development of electricity supply infrastructure*.**

The installed capacity for the Lagos Marina power station was 420KW as of 1920. Owing to increased load and demand for electricity, it was decided to look for a new site with reserve for expansion. The new power plant, which was the first coal fired power plant in Nigeria, was built and commissioned on 1st June 1923. The Marina site was shut down on 28th November 1923. The new power plant, which was described as the first major landmark in the development of electricity infrastructures in Nigeria, had a total installed capacity of 3.6MW. In 1924, the 3-phase, 4-wire, 50-cycle system was adopted to achieve an improved load balance (Francis Jackel 1997b).

The new power station further grew in installed capacity to 13.75MW. This development helped in providing the necessary electricity resource required by the Nigerian Railway workshops at the Ebute-metta and Iddo terminuses in Lagos (Francis Jackel 1997b).

Following the development of electrical power stations in Lagos, the next obvious place was the Plateau, to take care of the electricity needs of the Nigerian Eastern Railway (NER) workshops and coal mines, both in Enugu. The Plateau supply was a high-head hydro-electric power installation, employing quick start-up low maintenance water turbines. However, there were some initial constraints which included: inaccessibility constraints with remote location; high power transmission cost; and non-continuous river flow in dry season.

The Enugu power station was a coal-fired power plant and comprised of three 350KW Bellis & Morcom vertical reciprocating direct condensing steam engines steamed by Babcock & Wilcox boilers. The power plant was commissioned on 24th June 1924, while the township was lit on 24th December, 1924. Table 4.3 shows the electrical balance sheet for Enugu in 1924.

Table 4.3: Enugu electrical balance sheet 1924 (Data source: archives of the Nigerian Railway Corporation, 1997)

Electrical balance sheet (1924)	**Kilowatt hour (kWh)**
Electrical power consumed by power	139,905
Electrical power consumed by lighting	4,297
Electrical power lost to transmission	338
Electrical power surplus in consumption	17,020
Total electrical power generated	***161,560***

In 1925/26, a further 111.5KW was connected to the Enugu mains. In 1926/27, the extension was given to the European Hospital, while further extension to the mines had increased the load by 40%, 860KW for power and 110KW for lighting. In 1928/29, a 150KW AC set with condensing plant and auxiliaries were added, and power was extended to the secretariat, PWD, coal camp, and the Roman Catholic mission. Units generated were over 936MWh, and a 3.3KV electrical voltage line connected to residence of the Lieutenant Governor. This was extended to reach the barracks of the

Great Royal West African Frontier Force. Units topped the million mark by 1932/33 when the electrical engineer-in-chief of the Public Works Department took over the Enugu Electric and Power Plant from the railway from 1st November, 1932, and its accounts from 1st April 1933. Figure 4.3 shows the growth in units of electricity generated (in megawatt hours – MWh)) and installed capacity (in megawatts) from 1900 in Nigeria (Francis Jackel 1997b).

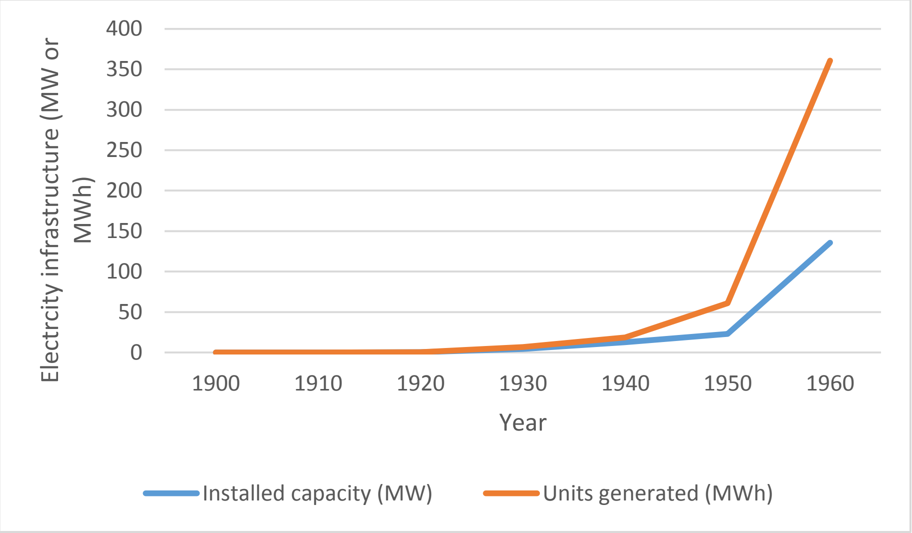

Figure 4.3: Electricity infrastructure growth in Nigeria across 1900 – 1960. (Data source: archives of the Nigerian Railway Corporation, 1997).

<u>4.3.3.3.</u> ***Energy demand and the development of transportation infrastructure***

The discovery of coal led to a rise in economic activities during this era. More coal-fired electrical generation plants were built, more mass railway transportation routes were opened, while other industries that depended on coal for the running of steam engines for other industrial processes sprang up.

Following the initial development of the railway in the previous era (1879 – 1898), the stage was set for the future development of railway transport, which aided economic development and trade. As of 1912, fourteen ports were operational without wharf or jetty. These were Obokun, Calabar, Bakama, Bonny, Buguma, Degema, Forcados, Koko, Ikang, Brass, Akassa, Lagos, Sapele, and Warri. In 1919, it was decided that

Apapa and Iddo (both in Lagos) were to serve as cargo and coal wharves, respectively. In 1923, a 750 feet screw pile wharf was constructed at Iddo (actually Ijora which is close to Iddo) and some eighteen acres of land were reclaimed. The wharf dealt with unloading of coal for railway, Ijora electricity power station, and ship's bunkering. This wharf was later taken over by the railway in 1924/25.

As of December 1918, the total harbour works expenditure stood at over £862k, which is approximately £52.0m using current estimates. As of December 1921, the expenditure had risen to £1.1m, about £45.0m using current estimates, which excludes dredger costs. The provision of harbours increased trading activities and imposed the need for bigger and more ports and harbour infrastructure. The movements of goods from the hinterlands to the ports also added to the increased demand for energy infrastructure provisions. As of 1913, trade through Lagos was valued at £13.4m, which is about £1.4 billion using current estimates. By 1923, the value had risen to £19.2m, which is about £990.1m using current estimates (Francis Jackel 1997b). This led to the development of the Apapa ports in Lagos, which started with the construction of three screw pile wharves for the Marine Department in 1925. The trade dynamics and movements of goods at the Lagos ports was quite complex. Table 4.4 shows some statistics of the complexity of movements in Lagos harbour in 1925/26 in terms of tonnage of goods. This also shows the complex dynamics of the need for harbour and ports infrastructure, which in turn imposes some pressure on the increased demand for energy.

Table 4.4: Complex movement of goods at Lagos harbour in 1925 - 1926 (Data source: archives of the Nigerian Railway Corporation, 1997)

Movement	**Tonnage**
Landed at Customs Quay	147,983
Landed at private wharves	142,906
Landed at gun powder magazine	170
Landed at kerosene magazine	7,780
Landed at petroleum magazine	7,786
Landed at Iddo wharf	55,454
Railway materials landed at Iddo wharf	7,167
Landed at Ijora wharf	2,362
Coal landed at Ijora wharf	106,219
Imports brought in through Iddo Railway station	49,886
Exports through Iddo wharf	195,603
Export through Apapa wharf	55,786
Aro stone traffic through Apapa	21,730

Road infrastructure came much later in Nigeria owing more to the fact that rail infrastructure was first built before roads were even considered. As such, there was a delay in the provision of road network infrastructure. Most of the road infrastructure network projects were financed in the closing decades of the 20^{th} century by oil revenues and not through taxation. Very little was done to develop road systems until 1925, due to the considerable costs of tackling swamps, bridging, grading the climbs into plateau areas, and proving the spate in the rainy season.

Providing road networks was quite challenging owing to the size of the country and the huge distances between cities. The longest capital-to-capital journey was 1,677km, while the longest road journey was from Badagry on the west of Lagos, to Kukawa, a place of historical importance in Bornu (1,922km). As of 1926, the Public Works Department (PWD) already had responsibility for 4,789 kilometers of road. As of 1930, there was already 6,075 kilometers of bituminous highways. As of 1937, plans were made for trunk road construction at 644 kilometers per annum. However, the great depression of the 1930s put an end to the scheme. As of 1946, there were 0.11

kilometers of road per square kilometer and 1.48 kilometers per thousand head of population; twelve years later, these figures had risen to 0.16 and 1.72 respectively (Francis Jackel 1997b).

While presenting a challenge, the vast distance between cities formed part of the justifications for a need for road infrastructure provisions. The progress made in road infrastructure provision had severe impact on increased fossil fuel consumption, which was mostly imported at this time. Table 4.5 shows the historical data of commercial vehicle and private car registration from 1937 – 1963 which highlights the transition from mass transportation to individualized transportation.

Table 4.5: Number of commercial and private vehicle registration in Nigeria across 1937 – 1963 (Data source: archives of the Nigerian Railway Corporation, 1997).

Year	Number of commercial vehicles	Number of private cars/taxis
1937	1,819	822
1948	1,593	2,199
1953	4,159	5,783
1958	7,220	7,459
1963	5,490	11,599

4.3.3.4. *Influences and drivers of energy infrastructure supply during the industrial era.*

During the industrial era, there were five vital drivers of energy infrastructure supply. These were:

1. Technological interventions
2. Changes in social practices
3. Policy and institutional interventions
4. Economic considerations
5. Energy resource options

Technological interventions

During this era, the use of metallurgical and electrical technology interventions in infrastructural provisions became further widespread. New railway infrastructure opened up the hinterlands and connected more towns which aided mass transportation of people and goods. The use of steam engines for transport and manufacturing applications were also evident in this era.

New electricity supply infrastructure was provided to cater for increased electricity demand. The existing steam plants were expanded in response to increased demand. This era also saw the introduction of new technology pathways for electrical energy generation. The discovery of coal in 1909 paved the way for the introduction of coal fired electrical power plants in (Lagos and Enugu) Nigeria. There were also plans during this era which paved the way for future hydroelectric power plants.

Changes in social practices

The introduction of various technological interventions during this era led to changes in social practices of Nigerians which became dependent on more dense energy sources. Indeed, some of these practices became more energy intensive. The provision of more road and rail infrastructure led to a change in commuting patterns from walking to the use of mass transportation models, such as railway lines. This period also saw a gradual change from mass transportation (in the beginning of the era) to individualized transportation (towards the end of the era) as evidenced in table 4.4. The change in commuting patterns led to increased demand for more transport infrastructure which also had some effects on increased demand for energy infrastructure supply.

Policy and institutional interventions

This era saw the introduction of several policies, implemented within institutional frameworks, which aided the eventual provision of targeted infrastructure (including energy). This era was dominated by colonial institutions, established to achieve specific infrastructural and policy targets (Aghalino 2000). Two institutions were pivotal in the provision of electricity infrastructure during this era:

1. Nigerian Electricity Supply Company (NESCO)
2. Nigerian Government Electricity Undertaking (NGEU)

Nigerian Electricity Supply Company (NESCO) was established in 1922 and tasked with the responsibility of developing electrical energy supply (generation) infrastructure. NESCO produced and sold bulk power for the townships of Bukuru (1936), and Vom (1944) which covers a total of 600 square miles (including the mines). The peak load rose to 12MW with an annual load factor of 60%. As of 1922, the Enugu building of NESCO was already in place, just off the railway workshops. Engines, dynamos, boilers and a riveted steel chimney were in position at an audited cost of over £103k, which is worth around £4.6m in current estimates. This power plant supplied electrical power to the mines from 1924.

The Nigerian Government Electricity Undertaking (NGEU) was established in 1946 to plan and implement the provision of electricity infrastructure by at least 200%. The aim was to ensure the provision of electricity to support industrialization. The implementation of this policy led to industrialization in the 1950s in Nigeria. Many manufacturing plants based their future growth projections on the electrical infrastructure expansion plans.

Economic considerations

Trade activities continued to grow during this era. This was evidenced by the complex movements of goods in and from the Lagos harbour as highlighted in table 4.3. The growth in trade was supported by increased agricultural productivity and the presence of small cottage industries.

The introduction of the new energy policy for the provision of more energy supply infrastructure was based purely on economic considerations, to support industrialization. The Nigerian Government Electricity Undertaking (NGEU) had the responsibility of planning and implementing this policy. Indeed, economic considerations from individuals and government and impacted on more demand for energy which then influenced more electricity infrastructure supply.

Energy resource options

During this era, there was a deliberate attempt by the Nigerian government (still under colonial rule) to conduct surveys aimed at exploring and searching for possible mineral reserves. This led to the discovery of coal in 1909.

The discovery of coal changed the electricity and transportation landscape. There was a shift to the use of coal fired power plants for electricity generation due to the availability of coal. The use of coal in cottage industries also increased. The transportation landscape was also affected by the discovery of coal as more locomotives depended on coal as the fuel source.

4.3.4. Late industrial era – mid to late 1900s.

This era saw more extensive use of energy, with dynamos and internal combustion engines as the main technology enablers for increased energy use. Indeed, with regards to transportation, there was a shift from mass transportation to individualized transportation. The discovery of crude oil also added a different dynamic in energy use as more infrastructure were provided as a result of the increased country income that came from crude oil.

4.3.4.1. *Dynamos and internal combustion engines as main drivers of energy demand*

Dynamos are the core inventions behind electrical generators, electrical motors, and internal combustion engines. Dynamos were the main technology driver which contributed to increased energy demand in the following areas:

- *Mechanical*: there was increased mechanical needs for manufacturing, with much more diverse types of manufactured products emerging, as well as demand for those products.
- *Electrical:* was being used increasingly in industry for manufacturing goods
- *Transport:* Individualized transportation with the internal combustion engine which was developing hand-in-hand with automobile.

4.3.4.2. *Primary energy resources and energy demand.*

This era saw the gradual decline of the use of coal for electricity generation, which was essentially a result of the discovery of crude oil, and the focus on renewable hydropower generation for electricity. From the 1930s, there were plans to develop the hydropower potential of Nigeria, which led to the later formation of the Niger Dams Authority (NDA) which was charged with developing the hydropower potential of Nigeria. The demand for crude oil was supported by the emerging transportation demand in other countries (petroleum export), as well as electricity generation. The discovery of primary energy sources, such as coal, crude oil, etc., in the first half of the 20th century in Nigeria was fostered by extensive surveys carried out by the British colonialists through the Public Works Department (PWD) to actively search for primary energy resources and minerals within the shores of Nigeria.

Oil and gas operations in Nigeria started in 1956 with the first commercial discovery of oil in Nigeria by Shell D'Arcy. However, in November 1938, a concession was signed with the same company to explore for possible petroleum resources within Nigeria's borders (Raji & Abejide 2014). After the discovery, Shell played a dominant role in the Nigerian oil industry up until 1971 when Nigeria joined the Organization of Petroleum Exporting Countries (OPEC), after which the country began to take a firmer control of its oil and gas resources.

The growing use of petroleum characterized this era due primarily to the penetration and wide spread use of internal combustion engines, as well as the increased use of petroleum (and its by-products) in the petro-chemical industry for production of plastics and other chemicals, which use the energy embedded in this product in form of petroleum. Figure 4.4 shows crude oil production, 1980 – 2000.

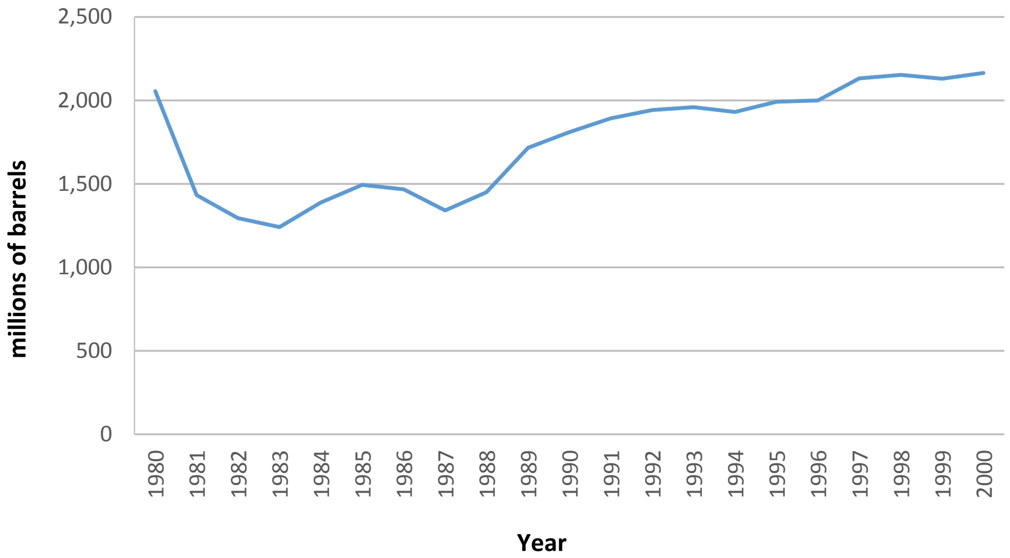

Figure 4.4: Nigeria's crude oil production across 1980 – 2000. (Data source: International Energy Agency, 2014).

Nigeria holds the largest natural gas reserves on the African continent, and was the fourth world leading exporter of liquefied natural gas in 2012 (US Energy Information Administration 2013). Nigeria's increased gas production was influenced by the creation of the Nigeria Liquefied Natural Gas Limited (NLNG) on 17th May 1989. The creation of NLNG paved the way for the installation of an LNG plant for production of natural gas to meet local demand for electricity generation, and also to meet export demand. Figure 4.5 shows the growth in the use of natural gas for electricity generation (1971 – 2000).

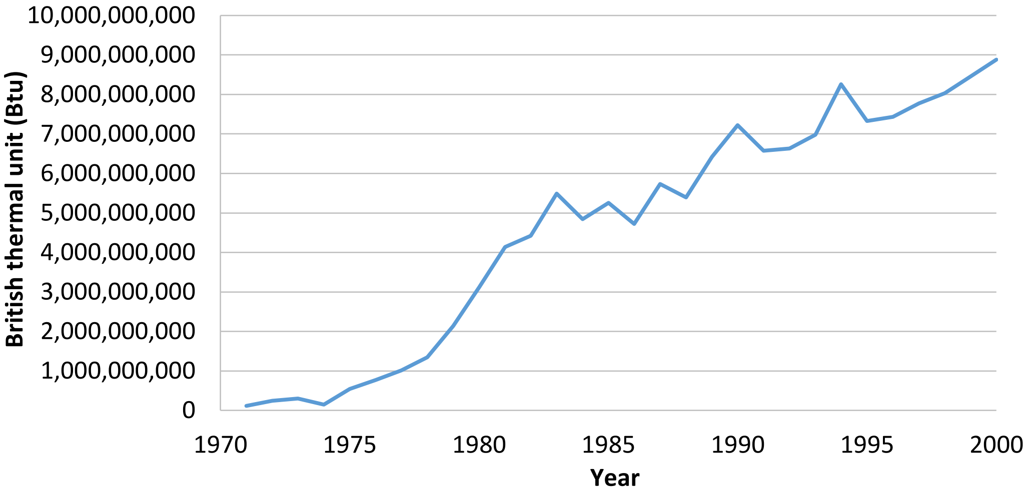

Figure 4.5: Natural gas for electricity production in Nigeria across 1971 - 2000 (Data /source: International Energy Agency, 2012).

During this era, there was increased demand for the primary energy resources that can do the kind of work that was required in transportation, electrical generation, and manufacturing. This reflected in:

- The continued use of coal for electricity generation – particularly within the first two decades of this era – and its reduced use for steam engines.
- The discovery and growing use of petroleum in the petrochemical industry, as well as transportation, due to the widespread use and penetration of the internal combustion engines.

The latter part of this era saw some diversification of primary energy resources. The higher demand for electricity warranted that there be diverse sources of energy for electrical infrastructure provisions. Essentially what was needed was electricity from whatever source, which led to the introduction of diverse technologies, such as thermal power plants, and the increasing growth of renewables (hydropower) in electrical power generation.

<u>4.3.4.3.</u> *Industrial estates growth and energy demand.*

In the 1970s, there was a reinvigoration of many industrial activities which had slowed down in the late 1960s owing to the Nigerian civil war, which lasted from 1967 – 1970. By the early 1970s, there were more than 2000 industries in Nigeria located across several industrial areas. Table 4.6 details the Nigerian industrial estates, as well as their average size and principal activities as of 1971.

Table 4.6: Industrial estates in Nigeria and their principal activities in 1971 (Source: archives of the Nigerian Railway Corporation, 1997).

Estate	Acreage	Principal activities
Kano	277	Groundnut mills, textiles, perfumery, plastics, tanning, minerals waters, carbon dioxide, Bata shoes, Raleigh Industries, retreading.
Kaduna	550	Textiles, brewing, London Brick pre-cast concrete, ordinance, building materials
Zaria	145	Oilseed processing, Nigerian Tobacco, toiletries, bicycle assembly,.
Jos	60	Tin smelting, pump assembly, twill jute snacks
Gusau	75	Textiles, rail head for Sokoto cement
Maiduguri	79	Oilseed processing, abattoir not within the estate, Chad fishery to be developed.
Ilorin	317	Philip Morris Tobacco, United Matches, Tate & Lyle.
Port Harcourt	2000	75% industrial, 25% residential. Alcan Aluminum, paints, enamelware, tyres & tubes, Costain (WA) furniture.
Aba	5	Textiles, soap, pharmaceuticals
Umuahia	31	Brewing, ceramics, not rail served
Emene	Unavailable	Turners Asbestos cement paper & sheet, iron & steel mill, Niger gas factory.
Onitsha	1518	Textiles, iron & steel, mineral waters, bus bodies. 50% residential and 50% industrial. Not rail served.
Ikeja	750	40% industrial, 60% residential. Textile, tyres, asbestos cement, enamelware, biscuits, paints, mosaics, Guinness, Aluminium products, drugs, galvanized work, livestock feeds, Bridon Group (Nigeria) wire-mesh and barbed wire, ICI Plastic pipes.
Mushin	230	Milk recycling, bicycle assembly, mattress factory, furniture, metal windows, not rail served.
Ilupeju	67	Light industries, rail served by Oshodi station.
Apapa	230	Established by Lagos Executive Development Board (LEDB), flour milling, automobile assembly, margarine, Sunlight/Lifebuoy/Lux toilet soaps, Nigerian ropes, Metalbox, West African Distillers, West African Cold Store, IBRU Seafoods.
Iganmu	200	Developed by LEDS, Star Brewery.

During this era, there was increased mechanical needs for manufacturing, with much more diverse types of manufactured products emerging, and demand for those products. The increase in manufacturing activities led to a corresponding demand for energy required for commercial and manufacturing hubs and estates. Government and policy makers during this era made some effort in the provision of energy infrastructure to support manufacturing. However, despite the provision, demand kept growing such that the growth of the manufacturing sector was limited by the insufficient energy infrastructure provision (Ku et al. 2010)

4.3.4.4. *Influences and drivers of energy infrastructure supply during the late industrial era.*

This era saw some drastic changes in energy infrastructure supply. These were influenced by the following:

1. Energy resource options
2. Technological interventions
3. Policy/institutional interventions
4. Societal practices and public values
5. Economic considerations

Energy resource options

The discovery of crude oil in commercial quantities in Nigeria in 1958 changed the entire energy landscape during this era. After the Nigerian independence and the civil war, there was a shift in the use of fuel from the use of coal to a greater dependence on natural gas and crude oil (and its by-products) for electricity generation and other industrial uses. Indeed, there were more options to choose from between coal, natural gas and crude oil. This era also saw the development of dams for hydroelectric power generation.

Technological interventions

During this era, dynamos and internal combustion engines played a key role as the major technology driver of changes in energy infrastructure supply. The extensive use of internal combustion engines for vehicles and road transportation impacted on fuel sources. This also led to extensive investment in road infrastructure and a gradual decline in the use of rail transport infrastructure.

During this era, new technological pathways were adopted for electrical energy generation. Extensive development of hydroelectric and thermal power plants was evidenced in this era. This era also saw a swift decline in the use of coal for electrical power generation and the retiring of several coal-fired power plants.

Policy/institutional interventions

This era saw the extensive use of policy and institutional frameworks as intervention tools in addressing issues of energy infrastructure supply. After the Second World War, there were increased problems in supply of electricity infrastructure to meet the growing demand. As such, the government had to intervene by creating a new department out of the Public Works Department with the aim of removing inevitable government restrictions and to take care of the essential growing developments. The Nigerian Government Electricity Undertaking (NGEU) was set up in 1946, to last for a period of five years, to pave the way for a future corporation. During this time, no further undertakings were commissioned but orders were placed and hydrological services were put in hand. The contemporary 10-year plan of 1946 – 1956 of the sum of £1.7m, which is about £66.3bn using current estimates, was designed by NGEU to increase capacity by 200%.

The Electricity Corporation of Nigeria (ECN) was created on 6th July 1950 under the ordinance No. 15 of 1950, charged with the responsibility to plan the development of

Nigeria's electrical energy potential in a manner as to provide the cheapest form of energy consistent with continuity of supply.

The first decade of this era saw the gradual and eventual hand over of most institutions controlled by the British colonial administrators to Nigerians (Mitchell 2011). This was in preparation for Nigeria's independence, which took effect from 1st October 1960. A few years after independence, Nigeria experienced a series of military coups and counter coups, which then led to the highly militarized decision-making structure during this era, as most of this era saw military institutions leading the decision and policy-making process (George et al. 2012; Ikpe 2014).

The Niger Dams Authority (NDA) was established in 1962 to develop Nigeria's hydropower potential. This paved the way for the development of hydroelectric power infrastructure in Nigeria with the building of several dams for irrigation, water supply and electricity generation

The National Electric Power Authority (NEPA) was established in 1st April 1972 which is a product of the merger of the Niger Dams Authority (NDA) and the Electricity Corporation of Nigeria (ECN). The merger actually took effect from 6th January 1973. The NEPA was a public company, owned and managed by the Nigerian government. All through this era, NEPA had responsibility for the provision, operation and maintenance of electricity infrastructure in Nigeria.

The Nigerian National Petroleum Corporation (NNPC) established on 1st April 1977 to participate and regulate Nigeria's petroleum industry. The role of the NNPC in regulating activities of players in the oil and gas sector had direct impact on electricity infrastructure provision since fuels required to power the electrical power plants depended on the dynamics of the downstream oil and gas sector.

The Energy Commission of Nigeria (ECN) was established by Act No. 62 of 1979, as amended by Act No. 32 of 1988 and Act No. 19 of 1989**,** to strategically plan and coordinate Nigeria's national policies on energy. The Energy Commission of Nigeria, since its formation, had focused on developing strategies and action plans to address Nigeria's energy challenges through promulgation of policies that can help Nigeria in having a diversified energy mix, improve energy efficiency and management, while encouraging indigenous and private sector participation in Nigeria's energy sector. The aims of the ECN is far from being achieved as there is still a huge gap between the desired objectives and what seems to have been achieved.

<u>Societal practices and public values</u>

In this era, there were swift changes with regards to social practices which impacted on energy demand and consumption. The public value for energy services was on the rise and energy was highly perceived as a public good. Education played a vital role in the changes in social practices and perceived public values for energy. There was an increase in the number of educational institutions at primary, secondary and tertiary levels. Educational institutions also needed energy for teaching and research.

With regards to commuting, there was a change in commuting patterns from mass transportation to individualized transportation. More people had their private vehicles for personal and business purposes. Aside the reasons of comfort and convenience, a major driver of change from mass transportation to individualized transportation were increased concern for security and safety. There were also changes in lifestyles and leisure that impacted on the energy consumption and use that leads to increased need demand for energy supply infrastructure.

Rapid population growth, migration and urbanization also impacted on changes in practices. Some towns and cities ended up becoming more cosmopolitan (such as Lagos). Multiplicity of diverse practices within cities, aided by migration and population growth, impacted on changes and provision of infrastructure for commuting (transport), leisure (recreation), learning (education), trading (commerce), etc. These practices impacted on energy use and increased demand for energy infrastructure supply.

Economic considerations

This period saw changes in trade and investment dynamics. The discovery of more natural resources paved the way for further trade activities and other economic considerations investments. Crude oil export started in the 1970s. Export of agricultural produce continued but at a reduced rate due to a shift in attention from agriculture to crude oil as the major income earner for the country. The produce that was now exported (crude oil) required a lot of energy for its exploration and production.

There was an increase in manufacturing activities during this era. Increased electricity requirements for industries posed a greater challenge with regards to electricity supply infrastructure. Inadequate supply during the latter part of this era impacted on many manufacturing and cottage industries. Industrial growth was pegged as a result of inadequate electricity supply infrastructure. Most industries opted for self-generation of electricity for their industrial needs. Indeed, this infrastructure deficit resulted in the need for planning and future provision of more electricity supply infrastructure.

4.3.5. Information (micro-processor) era – early 2000s.

This era is characterized by the extensive use, and need, of information systems and data storage infrastructure. More organizations have needed data centres and server rooms. Most manufacturing plants have migrated to semi-automated and automated platforms for their manufacturing processes, with the use of Programmable Logic Controllers (PLC) and other associated automation technologies. The need for automation, data storage, and information processing has thus added to increased demand for energy.

Mechanical needs in manufacturing and transportation also continued, with increasing demand for electrical power for the automation of manufacturing processes. A core characteristic of this era is the increasing value creation in the economy through information processing and transmission. This era has additionally seen the increasing use of petroleum products and the growing use of natural gas for electricity generation, as well as the growth of renewable energy generation.

With respect to transportation, this era is seeing an increasingly varied use of different forms of individualized and mass transport systems, which has been a major contributor to increased demand for crude oil. Another major contributor to the increased energy production has been the increased export demand for the primary energy resources, particularly crude oil and natural gas (EIA 2015) (Figure 4.6). In addition, the continuous growth in energy demand has been influenced by increased local consumption due to population growth and increased export demand.

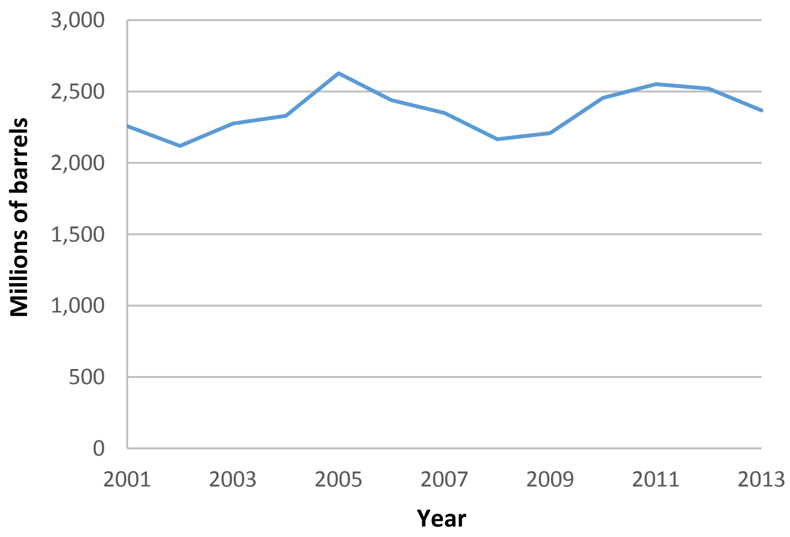

Figure 4.6: Crude oil production in Nigeria across 2001 – 2013 (Data source: International Energy Agency, 2014).

The consumption of natural gas for electricity generation is also changing during this era (Figure 4.7), with government policy focusing on the installation of gas-fired electrical power plants to address the challenge of energy access. This policy direction was initially informed by the high natural gas reserves of Nigeria.

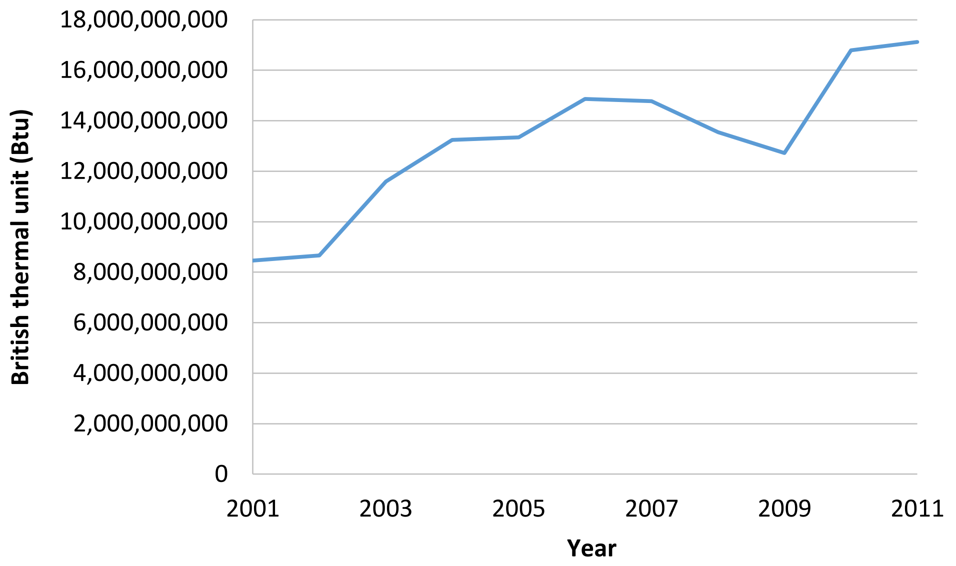

Figure 4.7: Natural gas used for electricity generation in Nigeria across 2001 – 2011 (Data source: International Energy Agency, 2012).

<u>4.3.5.1.</u> ***Influences and drivers of energy infrastructure supply during the information (micro-processor) era.***

During this era, four major drivers of energy systems change were noticeable:

1. Technological interventions
2. Policy and institutional interventions
3. Societal practices and public values
4. Economic considerations

<u>Technological considerations</u>

During this era, the use of microprocessor technology was on the rise which impacted on automation of processes in different sectors. In manufacturing, microprocessor technology aided the automation of many industrial processes. The use of Programmable Logic Controllers (PLCs), industrial sensors and other related technologies in manufacturing depended on microprocessor technology. The automation of several industrial processes aided increased production of goods. Even though there was more attention on energy efficiency and energy conservation measures, the introduction of these new technologies in manufacturing also impacted on electricity demand as more industries opted for automation to improve productivity.

Policy and institutional interventions

This era is characterized by democratic and civil institutions involved in the decision-making and policy process (Mitchell 2011). At the start of this era, two institutions emerged:

- Power Holding Company of Nigeria (PHCN).
- Nigerian Electricity Regulatory Commission (NERC)

Owing to inefficiencies in the Nigerian electricity sector, the Nigerian government started a process of unbundling the National Electric Power Authority (NEPA) in order to reduce government bureaucratic process in electricity supply infrastructure provision, operation and maintenance. The PHCN was established on 5th May 2005 as a holding company, owning the various divisions responsible for generation, transmission and distribution of electrical energy. This paved the way for the future privatization of the PHCN, with transfer and controls of some national electrical power assets by private companies. The privatization process also brought about some changes in models of electricity financing, operation and maintenance.

The NERC was established on 31st October 2007 as a regulatory body for the Nigerian power industry. The NERC has the responsibility for issuance of licenses and permits to market participants in the Nigerian electricity sector. They also ensure compliance to rules and regulatory guidelines in the Nigerian electricity sector.

Societal practices and public values.

This era saw lots of private investments in the provision of infrastructure to satisfy the increased demand for convenience and comfort. This was evidenced in the emergence of shopping malls, cinemas, nature reserves and parks. The emergence of these infrastructure posed more pressure on demand for energy. This era continued to experience increased migration and urbanization which posed some infrastructure challenges (including energy). Indeed, in this era, the public value for energy services had increased and people had more dependence on energy to fulfil and accomplish several social practices.

Economic considerations

In this era, the need for increased productivity led to the embrace of automation in the industrial and manufacturing sector. Economic consideration during this era was characterized by the need to address both internal (local) and external (export) demand for certain products. Indeed, this led to more manufacturing activities. Most industrial players had to invest in electrical generation plants to satisfy their electricity needs. Self-generation of electricity also impacted on cost of finished goods as some companies could not measure up to the economies of scale for increased production output.

4.4. DISCUSSIONS

Nigeria's energy transition has been influenced by a long history of trading relations, external interference in domestic decision-making, discovery of energy resources, and technology development. Interestingly, Lagos has been the epicentre for the emergence and development of new energy supply infrastructure, which then tends to diffuse through to the rest of country via existing/developing transport routes, in addition to diffusing within the geographic constraints offered by new oil/gas discoveries. Population growth also influenced demand for energy. Improved infrastructural provision, such as roads, schools, health facilities, etc., made the Nigerian people – over time – appreciate the need and usefulness of energy. Thus, more health awareness, education, and the quest to improve comfort and well-being, were main contributors to increased demand for energy (Shove 2003b).

Importantly, institutions have played a vital role in the provision of energy infrastructure and in Nigeria's energy transition. The establishment of the various institutions within each energy era was geared towards providing the needed infrastructure to support industrialization, to improve and ease mobility, to improve trading activities through the development of ports and harbours, and to support economic development. Institutions established during the different energy eras provided a technical basis for decision-making, but it is important to remember that these institutions (and their technical bases) only came to exist because of the (deemed) societal needs of each specific era. Each era had its own socio-technical contexts, which brought the technical (infrastructure) and the social together in fairly distinct ways (Van de Graaf 2013).

Indeed, these institutions were shaped both by energy needs and by significant external socio-political events which are unique to certain points of Nigeria's history. Such events certainly represent key moments of societal - and, consequently, infrastructural - change. For example, the First World War impacted on the sourcing of spare parts for the first set of electrical power plants. Some power plants needed to be cannibalized to keep others operational due to difficulty in getting spare parts during the war period. Moreover, during the Second World War, coal mining activities reduced, which led to the reduced use of coal for electricity generation during the war period.

Another key moment in the socio-technical evolution of Nigeria's energy infrastructure was Nigeria's independence on 1st October 1960, which also brought about changes in the institutional dimension of decision-making. Prior to 1960, there were more colonial institutions which started from the Public Works Department. There was the gradual hand-over of the various colonial institutions to Nigerian nationals for their operation and management in preparation for independence. After independence, the dynamics of decision-making changed and decisions were enacted through military decrees.

More recently, the potentially pivotal role of conflict and war was once again reiterated. Indeed, the Nigerian civil war (1967 – 1970) impacted on energy production. Whilst crude oil was discovered in commercial quantities in 1956, it was only after the Nigerian civil war that crude oil and natural gas production began in commercial quantities. By the early 2000s, the democratic process of decision-making, within many institutions, was gradually re-introduced.

In figure 4.8, a panoramic view of the Nigerian energy transition is presented. It highlights the role of various institutions in the provision of energy supply infrastructure. It also highlights the various technological, commercial, and end-use drivers of energy supply infrastructure, and the primary energy resource infrastructure used in satisfying the increased demand for energy. In the case of Nigeria, even though there were no clear long term strategies, institutional interventions provided the platform for the required transition to happen at different points of Nigeria’s energy history.

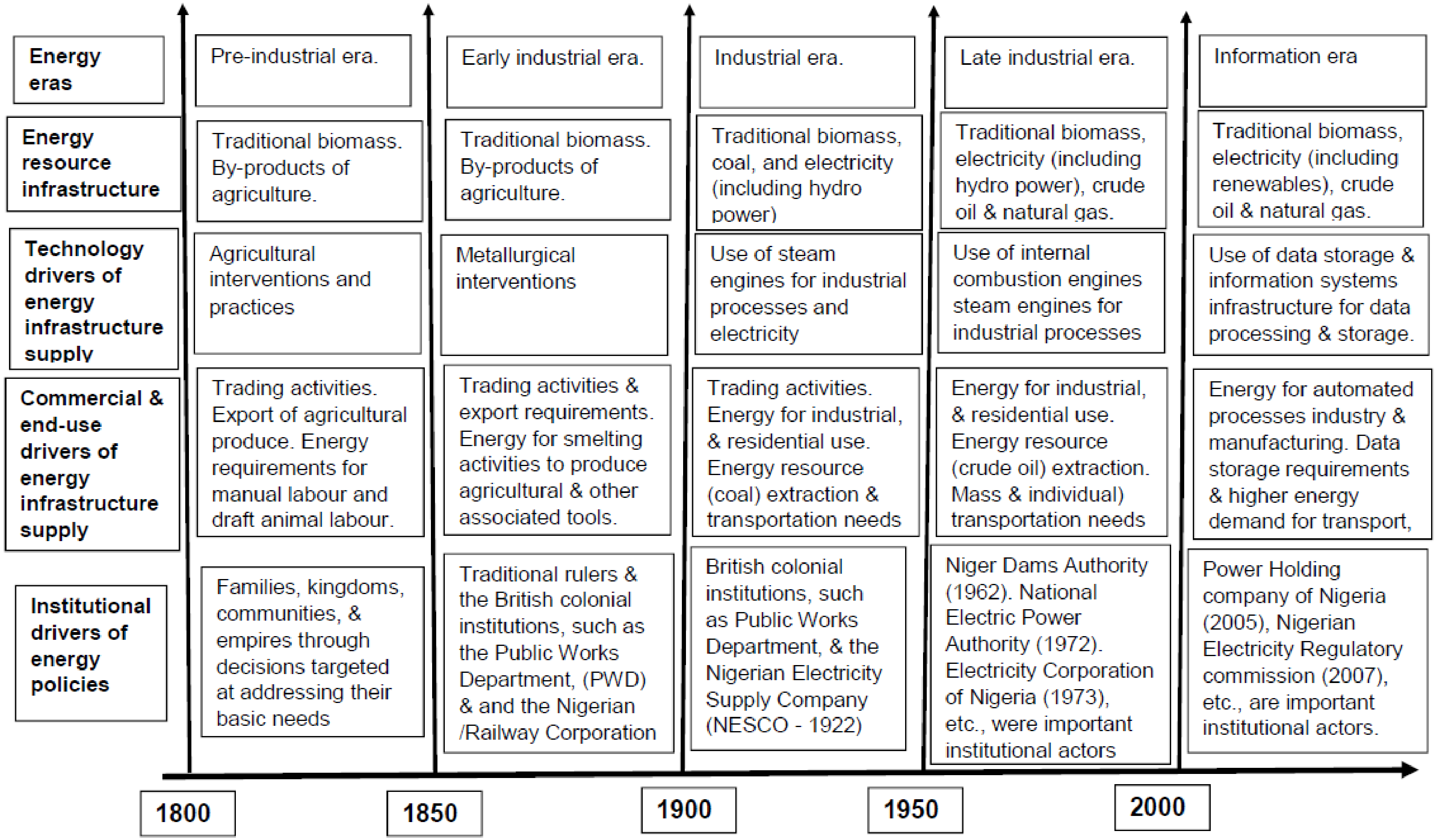

Figure 4.8. Summary of the various energy eras highlighting technology, end-use and institutional drivers of energy infrastructure supply

4.5. CONCLUSIONS

The study of the Nigerian energy transitions, with respect to energy supply infrastructure reveals a complex connection between resources, trade, institutions, and political structures. Indeed, in answering the thesis first sub-question, evolution and changes in Nigeria's energy supply infrastructure have been driven and influenced within the following contexts:

1. Policy and institutional interventions on energy
2. Technological interventions and energy technology pathways
3. Social (societal) practices and public values for energy
4. Available energy resource options
5. Economic considerations

Policy and institutional interventions have been one of the greatest contributors to changes and transformation in energy supply infrastructure systems. These policy interventions have come about as a result of the increasing need to address issues, such as energy access, energy security, decarbonizing future energy, and combating the effects of anthropogenic climate change and its consequences.

Technological interventions and different technological pathways have also contributed to changes in energy infrastructure systems in Nigeria over time. This started with the use of steam engines (up to early 1900s), coal fired power plants (up to mid-1900s) and thermal power plants (since the 1980s). The development of renewables (hydroelectric power) started in the mid-1900s. This development is deemed to continue due to national and international pressures to cause a shift to the use of renewables (including the use of solar photovoltaic cells, wind power and nuclear energies where applicable).

Public values for energy was driven more by the perceived (and actual) merit that provision of energy infrastructure conferred. Indeed, there were changes in societal and social practices brought about by the provision of electricity supply infrastructure. Some of these practices, such as commuting, trading and entertainment became more energy intensive. The provision of electricity infrastructure did not only help guaranty the continuation of these practices, but also aided its sophistication.

The increased use of primary energy resources was influenced more by the fact that the natural resources were available within the country. A secondary reason was the rising demand for energy. This is obvious from the series of changes and transition in the use of different primary energy sources (from coal, to crude oil, to natural gas) to satisfy the growing demand for energy. This same transition was also supported by, and influenced the creation of, several decision-making institutions within each era, as well as the policy direction of the government.

With regards to economic considerations, sustained public investment and leadership by public government institutions is still required to ensure that the provision of energy supply infrastructure is able to meet the changing needs of society, especially in the context of its development aspirations and future moments of change. I suggest that this can be, at least in part, enabled through more (effective) partnerships between public institutions, industry, and private investors, to improve access to energy and foster new clean energy technology development and deployment. There is also a role for governments, through public institutions, to provide economic incentives to increase energy infrastructure provision through promulgation of policies to aid private investment. Nevertheless, what this study implicitly makes clear is that whilst policymakers can prepare in all these sorts of ways (as part strategies to enable transitions in energy infrastructure), the most significant changes in the past have actually come from unforeseen socio-politico-technological changes that have had ripple effects into the provision of energy infrastructure.

As such, a key contribution of this Nigerian development case study is its empirical evidence that emphasizes how a better understanding of historic/future changes to energy infrastructure is actually enabled through studying the changing needs and wants of society.

Chapter 5 POLICY MAKING AND ENERGY INFRASTRUCTURE CHANGE: A NIGERIAN CASE STUDY OF ENERGY GOVERNANCE IN THE ELECTRICITY SECTOR.

In answering the central research question, this chapter focusses on addressing the second sub-aim which is: "what exactly constitute the practice of policy making and how has this influenced electricity supply infrastructure and energy policy?" Table 5.1 presents a summary of the sub-question being addressed, the guiding theories and the guiding questions which serve as point of departure in addressing the chapter aim.

Table 5.1: Summary of chapter aim and guiding theories

Sub-question (chapter aim)	**Guiding theories**	**Guiding question (point of departure).**
What exactly constitute the practice of policy making, and how has this influenced electricity supply infrastructure provision and energy policy?	Social psychology	What do people (and policy makers) think about with respect to energy?
	Institutions	How do institutions respond to energy infrastructure challenges?
	Socio-technical transitions	What are the influences impacting on changes In energy infrastructure governance?
	Techno-economics	How has cost/benefits analysis impacted on energy infrastructure decisions?

5.1. INTRODUCTION

There is certainly a need to focus on the supply side approach to energy in tackling environmental problems, such as: pollution, global warming, climate change, natural resource depletion, loss of biodiversity, etc. This presents an interesting platform to highlight the political and policy opportunities that come with looking at the supply side of energy (Schock & Sims 2007). What are the implications of the transitions that are going on in many parts of the world in relation to energy dynamics? What are the implications of constancy within global energy policy? What are the policy interests of most nations? What is going on within the global energy market? Does it continue to be constant? These questions are important in exploring the learnings from the historical effects of policy decisions which can guide policy makers (and other relevant stakeholders) in making choices that can produce the right effects but often with unintended consequences (Doukas et al. 2008).

The increasing role of governments in energy decisions cannot be overemphasized (Florini & Sovacool 2009). This is enacted through regulations and other forms of controls they have in the energy market (European Union 2015). However, do policy makers understand energy well enough to make smart decisions? What impact has the policy making process had on energy policy and energy infrastructure provision over time (in developed and developing countries)? Not enough works have been done that links policy decision dynamics and their influences on energy infrastructure provisions and energy policy from a developing country perspective (Doukas & Ballesteros 2015). Bale argues that social and institutional elements needs to be incorporated when addressing questions at the technology-policy-behaviour interface (Bale et al. 2015). Connors also argues that *energy is an essential component of economic development, and energy sector decisions and practices will play a central role in determining the sustainability of development in every country, region and sector* (Connors 2015). Some sectors that influences and impacts on energy infrastructure provision such as: transport; industry (manufacturing); residential; and resource extraction and production (such as mining activities), also informs the policy decisions of the government in this regard (Schock & Sims 2007).

This chapter empirically explores the role and influences of the historical policy decisions process(es), how they influenced transition in energy infrastructure provision, and their corresponding impact on energy policy transitions by seeking to answer the question:

- *What exactly constitute the practice of policy making, and how has this influenced electricity supply infrastructure provision and energy policy?*

Doukas et al. (2008) argues that in the policy framework, energy policy should compromise desirable objectives and encourage close collaboration between current stakeholders who are also key energy players (e.g. energy users, energy companies, government), in order to confront and tackle the various obstacles. This is important in studying the Nigerian case as there seems to be a general hypothesis that the lingering challenges in the Nigerian energy sector were aggravated by two major issues:

- *Stakeholder engagement* – through conversations with stakeholders, getting them involved and buying into the target plan or goal. Stakeholder engagement decayed over time, which led to failure of consensus agreement on policy plans and implementation (Sherriff 2012; Alberta Energy Regulator 2015).
- *Taking decisions* – particularly with respect to formulation and implementation of policies driven by strategic energy plan(s) with stakeholder involvement (Cockrel 1997; Kunreuther & Weber 2014).

The aforementioned are important particularly in addressing issues of energy infrastructure provision, climate policy, climate change, energy investment, and other interconnected issues (Reddy et al. 2000).

There are lots of influences that govern the provision of energy infrastructure (Markard 2011). One of the biggest stakeholders in the value chain of energy infrastructure provisions is policy makers (Verrastro et al. 2010). Understanding their role in the policy decision process and how it affects energy infrastructure provision is critical if we are to have a better understanding of the wider range of influences and actors governing energy transitions (Scott et al. 2011; Platzer 2015). In selecting a case study to more deeply explore such issues, the unique history of energy in Nigeria (and its associated political influences) makes it both a unique case with lots of applicable lessons for other developing and emerging countries (as evidenced in chapter 4 of this thesis).

Some methodological considerations are presented (in section 5.2) before discussing the salient intra-country and inter-country induced factors influencing the Nigerian energy industry performance (in sections 5.3 and 5.4), including discussions of how policy decision dynamics impacted on the Nigerian energy industry. This chapter then concludes by highlighting some concerns and uncertainties associated with the influences of the policy decision process in the governance of energy going forward (section 5.5).

5.2. METHODOLOGY

This section presents a breakdown of methods used for data collection and analysis.

5.2.1. Data collection

Qualitative data were collected via in-depth semi-structured interviews with open ended questions (Laforest 2009). Semi structured interview was adopted so as to ensure that the vital aspects of the research question are covered while still giving room for discussions which could provide more insights into other aspects which may not be directly linked to the research question, but could be very vital in the research (Zorn 2008). The qualitative data collected had the following features:

Aim - was to gather historical data - based on the lived experiences of the participants - in order to ascertain influences of policy making on energy supply infrastructure provisions, with particular emphasis on the electricity sector.

Target participants - The target participants for the interview were people who have been involved in policy making (either directly or indirectly) in the past, and those who have been involved in specifying the technical requirements, as well as maintaining existing energy/electricity infrastructure, with specific focus on people from age 50 and above. The choice of the age limit is buttressed by the fact that the research aimed to get more qualitative data as far back as possible. The participants were composed of two groups of people which were:

- Those who have been involved either directly or indirectly in the policy (formulation or implementation) process.
- Those who have (either directly or indirectly) been major stakeholders in building, maintaining, or prescribing the technicalities of the historical energy/electricity infrastructure which forms part of the Nigerian energy history

On the part of policy makers, emphasis was placed on the following categories of people:

- Current and past policy makers who were members of parliament at the federal (country) and state levels.
- Current and past directors and permanent secretaries of relevant government ministries and parastatals.
- Current and past special assistants, ministers, advisers, and consultants to government.

The research participants came from diverse backgrounds. Samples of the roles of some of the research participants include:

- Members of the federal and state houses of assembly. The participant with the minimum experience in this category has 12 years legislative experience.
- Special assistant/adviser to the president on policy implementation.
- Directors of some important government agencies and parastatals such as the Nigerian Electricity Regulatory Commission (NERC).
- General Managers (GM's) and Chief Executive Officers (CEOs) of some power generation plants and distribution networks such as the Transmission Company of Nigeria (TCN), among others. The average experience of the participants in this category that were interviewed is 20 years.

The full details of the data collection tools and techniques, as well as rationale for the selection of data collection tools (interviews) have been presented in chapter 3.

5.2.2. Data analysis

Qualitative data collected during research can be analysed in different ways using one or more of the various methods such as: thematic analysis, descriptive approach, or more in-depth methods. Thematic data analysis was used for the analysis of qualitative data collected in the course of this research.

Thematic data analysis looks across all the generated data to see or identify the common issues that occur (Fereday & Muir-Cochrane 2006). It seeks to find the main theme(s) that summarizes all of the views of the data collected. This method is the most commonly used for descriptive qualitative projects and research. Thematic analysis was chosen because it was better suited to the particular layer of critical realism (real layer) and the theoretical lenses (social psychology, social practices and institutional theory) under consideration.

How were the themes generated?

The themes from the interviews were generated in two ways:

1. By highlighting and noting down some recurring notions from the interviewees during the interviews (see an example in appendix 9).
2. By pen and paper coding of the interview notes developed immediately after each interview to identify common patterns and themes (see an example in appendix 8).

Some recurring notions from the interviews include:

1. “We have a bunch of incompetent fellows.” This point to issues of practical knowledge of energy policy making, energy legislation and recruiting people into the policy space.
2. ‘There is no policy consistency, the rules are not clear’. This point to issues of energy legislation, expectations and future visions of the energy industry.
3. ‘Some foreign governments that offered support gave conditions that must be fulfilled’. This point to the changing nature of the international aid landscape.
4. ‘The Millennium Development Goals target for us also included addressing energy poverty and access issues’. This point to the influence of the Sustainable Development Goals of the United Nations.

Indeed, the themes generated were a result of the synchrony between the noted recurring notions made by the interviewees during each interview and those discovered in the course of the pen and paper coding of the interview notes. Appendix 9 shows some examples of recurring themes and notions during the interviews. The interview protocol is presented in appendix 4, while the coding frame for the interviews is presented in appendix 10.

Notes of very important points (interview notes) were taken during each interview rather than audio recording each interview (Clausen 2012). This approach was essential in encouraging the interviewees to be open and speak freely. This is quite important in the cultural context of Nigeria, where people can be quite reserved when they discover that their conversation is being recorded (Halcomb & Davidson 2006). The data (interview notes) collected (using pen and paper during the interviews) were transcribed and expanded upon immediately after the interviews, in order to ensure that the vital points discussed during the interviews were captured. It should also be noted that the interviews were conducted during a very tensed period in Nigeria (electioneering period). The election period in Nigeria last for one year before the main handover date until six months after the handover date, when the political climate would have settled. This has some implications as people tend to be less open to discussions of this sort during such tense period.

5.3. INTRA-COUNTRY INDUCED FACTORS INFLUENCING THE NIGERIAN ENERGY INDUSTRY PERFORMANCE

The analysis of the interview notes yielded five main themes, which stood out as the key intra-country induced factors that were influencing the Nigerian energy industry performance. From the point of view of theory, the themes generated underpins: institutional theory (institutional frameworks for policy making); theory of practices (viewing policy making as a practice); and social psychology (individual and collective biases of policy makers in the policy making process). Indeed, the themes generated can help us speculate actions in the real layer. These five themes, which gives a better understanding of the internal processes and practices in relation to energy, are:

- Competencies, - i.e. practical knowledge of energy policy making.
- Expectations, - i.e. past, present and future expectations from the energy industry.
- Legislation, - i.e. institutionalized (and unwritten) rules/procedures in the energy industry.

- Future visions, - i.e. future visions of the energy industry/energy market.
- Recruiting experts, - i.e. recruiting new energy and public policy makers.

The following sub-sections (5.3.1 - 5.3.5) expand on each of these themes in turn, including presenting evidence for how they have influenced, and are influencing, the Nigerian energy industry's performance and development via policymaking.

5.3.1. Competencies - practical knowledge of energy policy making.

The first of the key influences resulting from the research is *energy competency* which presents itself in the form of *lack of knowledge and competencies in energy policy making* (Hood et al. 2002). Competency entails the ability to use and apply related skills, abilities, and knowledge to perform a defined task or critical work function. In the same way, energy competency entails all the requisite skills and abilities required to successfully manage and govern the affairs of the energy industry (Van Vooren 2011).

There are two essential areas of competency which needs to reflect the skills set of those involved in energy policy making and the governance of energy infrastructure provision. These are:

- *Planning for our energy future* – which involves formulation and implementation of strategies, innovation, creativity, and change orientation (Great Britain Department of Trade and Industry 2003).
- *Engaging stakeholders* – which include communication, consultations, building relationships, and providing leadership (UNEP 2011; Conde et al. 2004).

This study reveals that, within the Nigerian context, energy competency challenge manifests in three ways:

1. Non-professionals actors appointed as energy ministers, who try to adopt a dogmatic approach in addressing the problems in the sector. This leadership approach only led to a “watch and see if this will work” syndrome by many stakeholders in that industry, which eventually led to further failure and decay of the Nigerian energy sector (Whitmarsh et al. 2009).
2. Employing the services of people in the legal profession (for preparation and drafting of energy policies) who neither have the requisite knowledge and competencies, nor understand the workings of the energy sector and the global norms and regulations governing the sectors activities (Florini & Sovacool 2009). A very good example of such lack of competence and knowledge reflected in the removal of maximum demand charge on electricity for industrial user in Nigeria during the sector reforms which started much seriously in 2005. This contradicts the global norm as is common in the global electricity supply industry to include a maximum demand charge in order to discourage industrial users from consistently reaching the maximum peak demand for electricity (We Energies 2015). This is also practiced in different countries as it is a general rule in electrical engineering.
3. Ignoring the inputs of those who have been involved in the historical development (and decay) of the current energy supply infrastructure.

The importance of engaging and aligning with stakeholders cannot be overemphasized (Goldthau 2014). In the past, there used to be some degree of alignment between policy makers (through designated governments institutions) and those responsible for maintaining the existing energy infrastructure. This was reflected in the cordial relationship that existed between the then Nigerian Electrical Power Authority (NEPA), and the Ministry of Establishments (which is an arm of the federal government of Nigeria).

> At that time, anyone recruited by the NEPA had to get his/her employment regularized by the Ministry of Establishments.
>
> (Extract from interview notes)

This meant there had to be a good cordial working relationship for things to move on smoothly. The government, through the Ministry of Establishment, as well as the NEPA had several joint projects, as such; policy makers involved in taking decisions on electricity infrastructure on the part of the government were also major stakeholders in the business of managing the entire electrical network.

> …the situation however collapsed over the decades, just like many other sectors, and today, every Nigerian suffers the effect of a system where policy makers (who are not competent on the subject matter) parade themselves as subject matter experts, and take decisions without consulting other stakeholders who have the requisite knowledge and experience.
>
> (Extract from interview notes)

Indeed, the lack of competencies and deficiencies in stakeholder engagements in the Nigerian energy sector is reflected by (Durand 2000; Dur 2001):

- Improper audits of the electrical network infrastructure before they were sold.
- Sale of power plants and other electrical network infrastructure to individuals and companies who do not understand the dynamics of energy business.
- Inconsistencies in policy direction on the electrical power sector; among others.

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5.3.2. Expectations – past, present, and future expectations from the energy industry

In considering the expectations from within the energy industry, one is pulled towards the trust, confidence, and belief that stakeholders (including energy providers and consumers) have in a future direction to travel relating to energy supply and demand. Some of these expectations may include: moderate and affordable energy bills; security of energy supply; and non-disruption; to name only a few (Toth & Rogner 2006; Reddy et al. 2000)

There were many industries in Nigeria in the early 1970s, mainly because industrialization was at its peak at that point (Ogundele et al. 2014). Electricity demand was growing, and there was need for fidelity to the implementation of the national planning agenda on electrical power in order to ensure that industries and the industrialization process were supported (Stern & Kander 2012). Planning had been in place since the 1920s that set out a route for the future growth of energy demand and consumption. Most of the national planning that was done in Nigeria were done during the colonial times (Marcellus 2009). After the 1970s, Nigeria experienced a massive de-industrialization caused not only by the impact of some decisions under the military rule (such as divesting from agriculture and focussing on oil as the major economic resource), but also by insufficient supply of electricity to meet the growing industrial demand and growth projections. As such, energy consumption declined due to lack of electricity which led to de-industrialization (Stern 2004).

What is currently projected as the estimated electricity demand is something very fictitious and can never reflect what the future will have to hold. This is especially true for the Nigerian case, where constant and reliable source of electricity and energy has not yet been experienced. Indeed, the provision of more energy infrastructure will stimulate a new wave of (energy) demand. More people who were not able to use certain kinds of equipment due to non-provision of electrical power will start to use them, those who have relied on local generating sets for electricity generation for their businesses will start to weigh the options of connecting to the public utility, among other interconnected factors, which will really impact on a new wave of increased demand (Sambo 2008; Stern 2004).

During the times of the Electricity Commission of Nigeria (ECN) and the Niger Dams Authority (NDA), electrical network infrastructure provisions were in line with the demand. There was clear planning, and the projections and plans were followed. As such, demand and supply of electrical energy were commensurate. As population grew, improperly formed policies ended up as the real bottle-neck to the advancement and provision of new energy infrastructure to meet the rising level of demand (DFID 2002):

> It should be noted that demand for energy (particularly electricity) was quite low at some point in the history of Nigeria. The focus was more on electrical energy requirements for lighting in residential areas and for a few workshops and industries.
>
> (Extract from interview notes)

However, the oil boom in the 1970s led to a growth in the demand for energy in the following ways:

- There were more industries springing up during that period (particularly textile industries), thus, increasing industrial demand for electricity infrastructure (Ogundele et al. 2014).
- The establishment of more petrochemical industries (Abdullahi & Galadima 2014).
- Increased demand for residential use outside of lighting applications.
- More enrolment into schools (which meant improved knowledge of the importance of energy access as well as the need to provide electricity to schools for teaching, learning, and research).
- Improved living standards and earnings of the Nigerian people

- Explosion in academic activities.
- Lots of structures and industries springing up.
- People striving to improve their comfort levels.

While growth in demand was being experienced, the installed capacity of the electrical network infrastructure remained static as there were no new investments for some decades. In recent times, the electrical supply network has been overstretched as the capacity is limited. Throughout the *no-show* decades, the only project that was done was the Lagos thermal station (Egbin gas turbine project) which started in 1986 and was completed in 1996, making it the biggest thermal power station in Nigeria. The Egbin power plant was built after almost 30 years of provision of the major hydro power plants (Shiroro and Kainji). Even with the provision of the Egbin power plant, demand was still far greater than supply (Oladipo & Olowu 2014).

> Nigeria experienced a null period from the mid-1980s to the early 2000s. During this period, the only power plant that was commissioned was the Shiroro hydro power plant. No improvement was done on the network infrastructure, neither was there any plan or budget for electrical network infrastructure improvement.
>
> (Extract from interview notes)

Several studies have shown that what Nigeria needs is a diversified energy mix. Nigeria has ample primary energy resources that can be used for electricity generation which are not currently well explored (some of them were explored in the past and later abandoned). Power plants can be built using different energy resources with focus on siting the plant close to where the resources are located (coal fired plants in Enugu and environs, hydro power around the Mambila plateau, gas fired power plants around the Niger Delta region, among others). These opportunities have led to the entry of many global energy players to Nigeria as the energy market is huge, very much untapped, and quite promising (USAID 2015). The viability of current and future investments in this sector is a major motivating factor for investors despite regulatory challenges.

<u>5.3.3.</u> Legislation - institutionalized (and unwritten) rules/procedures.

Energy legislation deals with setting out regulatory frameworks for the governance of the energy industry and the energy market (Thomson 2010). These regulatory frameworks come in the forms of: national electricity laws which establishes obligations for the electricity network and the national electricity market (Outhred 2004); national energy retail law which provides a schedule that regulates the sale and supply of energy to retail customers; and national gas law which establishes obligations for gas wholesale market and gas pipelines (Kenny et al. 2013). These regulatory framework forms part of the constitutive elements of the institutionalized (and unwritten) rules in the governance of the energy market.

Indeed, inasmuch as there are federal laws governing the activities of the energy supply and extractive industry, the internal mechanisms and dynamics of policy decisions at the state and federal levels also impacts (to some extent) on the workings of the energy industry. At federal level, members of the legislature can propose, and sponsor bills. They explore all sorts of mechanisms and lobbying processes to ensure the bill they sponsor is passed to law. At state level, most bills originate from the executive arm of the state government. The bills are then passed to the state legislature for the legislative process that gets the bills to become laws (Khemani 2001). The state legislatures have very limited powers to recommend possible projects and ideas through bills. When they try, the state executive interprets it as an infringement on their responsibility, and also as a message that they are incompetent. This is one of the causes of friction between most state legislative assemblies and the state executive (Mba 2014). It is obvious that at the state level, political powers lie more in the executive arm for policy formulation and implementation. Indeed, key players in the energy industry capitalize on these internal workings to explore the best lobbying mechanisms to deploy in gaining some sort of advantage, both at the federal and state levels, in addressing their issue position. However, there is still a lack of clarity regarding people's expectations from legislators at state level that needs further consideration:

> Nigerians expect so much from the state legislators, not realizing that they (the people) stripped them (the state legislators) of everything that can make them influence the decisions and happenings as regards the governing of the state. The only way they can influence decisions is by frustrating the passage of a bill.
>
> (Extract from interview notes)

Lagos is the only state where the budget and spending of the legislature is autonomous and independent of the state executive (governor) for approval. In all the other states of the federation, the governor has to approve the spending and budget of the state legislature. There are usually frictions between the two arms of government at the state level that are caused by the lobbying process(es) employed by either party to satisfy their interests. When the executive governor needs a bill to be passed to law that is being frustrated by the state legislator, he can decide not to approve their budget or spending, thus, using that as a tool for lobbying and vice versa (Mbaya et al. 2013).

The aforementioned systems also affect policy decisions in the energy supply and extractive industry. It is all a question of satisfying the interests of stakeholders in that sector. The politics of satisfaction of interests really comes to play when there are no clear policies, guidelines, or framework on ground to support certain investments or infrastructure provisions. What really happens is that the investing parties, through some lobbying mechanisms, use government instruments to make pronouncements to their favour. This sort of unwritten rule or manner of acting in order to channel decisions in favour of a few parties is one of those things that characterize this sector. What happens to those who do not have strong links in government and the political space? How does a “normal” investor understand these underlying dynamics by looking only at market indices? These are some of the interesting challenges new investors in this sector are faced with (Ploch 2013).

5.3.4. Future visions - future vision of the energy industry/energy market

Energy future vision entails the regulatory, technological, social, economic, and political aspects that forms and informs our vision and expectations to satisfy our unappeasable hunger for energy both now and in the future (World Economic Forum 2013). It is what informs the development, growth, and lifestyles of people and society. Energy vision is the price of continuous thought on how to address issues of: inefficient centralized power plants; energy pollution; and expensive energy (Canadian Electricity Association 2014; Business Roundtable 2013).

It is argued that the energy future of many nations will include: distributed, accessible, digital, and connected energy sources (Dennison 1995). However, in what way are Nigerian policy makers tackling this issue? There was very limited action for a while by policy makers in tackling the decaying situation of the energy sector (Qureshi 2011). Successive governments had the mind-set that appointing new energy ministers and directors at the helm of affairs of major institutions was what was required to address the decaying energy situation, however, the situation only worsened as there were challenges of knowledge and competence of the workings of the industry. Policy makers adopted the blame culture rather than focusing on addressing the core issues in the electricity sector in particular, and the energy sector in general, as such, the problem was only aggravated (Hood et al. 2002). No serious attempts were made to correct the anomalies, neither were new power plants built to accommodate the increased demand. However, these anomalies open up new frontiers of opportunities for more (public and private) stakeholders with business interests both at present and in the future (IEA 2012b).

Paving the way for the effective future governance of the energy and electricity market started more seriously in 2005.

> After a long period, there were some serious attempts made in 2005, with a clear roadmap in correcting the anomalies which led to the electrical power sector reforms.
>
> (Extract from interview notes)

However, the reforms were placed on hold as the President that came into power in 2007 hailed from a region of the country where it is believed that energy and electricity provision is, and should be, the sole responsibility of the government. The belief was that if the sector eventually becomes privatized, energy bills will sky-rocket and many Nigerians won't be able to afford it. This led to a halt in the process of implementation of the roadmap for some years until the Goodluck Jonathan administration managed to complete the first phase of the privatization of the electrical power utilities and network. However, some quarters argued that there were some fundamental errors with the reforms and the process of privatization, some of which includes:

- 100% sale of existing power plants.
- No new investments in infrastructures to compete with the existing companies/plants.
- Various parts of the electrical power network was sold to businessmen and not to those who have knowledge of energy/electricity supply business
- Initial audit that was done before the privatization was carried out in a hurry and did not capture all of the various aspects of the electrical power network infrastructure challenges.

- The external investors failed to carry out their own independent audits to ascertain the value of the electrical network infrastructure before purchasing them.
- Electrical power network infrastructures were sold at very cheap rates.

It is also argued that some of the errors were even extended to electrical network infrastructure provision.

> Some interesting things (which form part of the effects of ineffective planning) were the building of power plant (Omotosho power plant in Ondo state, Southwest Nigeria) without consideration for gas infrastructure to power the electrical power plant.
>
> (Extract from interview notes)

During the decades of non-provision of new energy supply infrastructure, there was also the challenge of non-investment in the periodic turn-around maintenance of the power plants (Kumar et al. 2012). This led to a further drop in the overall efficiency of most of the existing power plants to about 50%. Due to the increased demand and the inability to cope in terms of supply, backup power plants were brought to the mainstream. Even at that, the demand for electrical energy still by far outweighed the supply (Sambo 2008). The identified challenges open up business opportunities for highly competent businesses such as:

- Businesses involved in energy conservation, management, and efficiency services.
- Original Equipment Manufacturers (OEMs) involved in production and sale of various products and equipment for building and revamping the electrical power network.

- Consultants and energy experts who can assist government in the area of policy direction and effective implementation of such policies to serve as key driver of investment, and provision of the required infrastructure.

The interviewees were thus keen to emphasize that the future was still bright in Nigeria. These sorts of business opportunities were believed to be a major incentive, especially for international energy-related companies who were interested in having a (or expanding their presence in Nigeria.

5.3.5. Recruiting experts - recruiting new energy and public policy makers.

Public policy essentially entails customary and institutional (written and unwritten) laws channelled towards achieving public common good. It is a means employed by governments to maintain public order and to serve their citizens guided by constitutional rules (Cockrel 1997). The term ‘public policy’ is used to describe a collection of mandates, regulations, or laws, established through a political process. Energy policies are subsets of public policies. Energy policies are comprised of rules, regulations, mandates, and laws promulgated to govern the affairs of the energy industry and the energy market (Supple & Sheikh 2010). These rules and mandates are promulgated through a political process. For this reason, it is crucial to have competent experts, in the public policy space in general, and the energy policy space in particular, in order to ensure the right laws are promulgated that can serve a nations citizens while protecting the common good (IEA 2012b).

The challenges in the Nigerian energy sector led different stakeholders to carry out extensive studies on what needed to be done in addressing the problems being confronted (European Commission 2013). The first democratically elected president, after almost three decades of military rule tried different means in addressing the issues. After several trials of different solution recipes, a crucial (and quite evident) step taken was the recruitment of new people into the public policy space to help drive the affairs of the various sectors of the Nigerian economy (Edwards 2008).

> The Olusegun Obasanjo's administration paid attention, after almost six (6) years of learning, on the need to recruit the right subject matter experts to run the affairs of the energy sector.
>
> (Extract from interview notes)

At that time, he appointed a very experienced and knowledgeable person as the energy minister. This recruitment, among other similar recruitments, saw the preparation and advancement of the electrical power sector reform roadmap which became the template for the eventual implementation of the sector reforms and privatization. Unfortunately, the time left during his administration was not enough to see through the entire process of the reforms. This same idea of recruiting subject matter experts into policy making by the then president was also replicated in other ministries and government agencies. As such, for the very first time, in a long while in the history of the country, Nigeria had a new set of technocrats managing the different aspects of her economy, with the very strong backing and support of the recruiter, the president. This led to unprecedented progress in the economy and the various aspects of the life of Nigeria. It is worthy of note that those recruited into the fabrics of the decision making process during this period are currently handling much more responsibilities in the country's polity and are now major stakeholders in the country's affairs. It should be noted that some of the interviewees expressed their displeasure at the initial appointment of some of the appointees on the grounds of inexperience in political affairs. However, at the point of the interviews, they did acknowledge that it was one of he best things that happened to Nigeria.

With reference to the interviews conducted, there are three resounding features the interviewees stressed as the guiding principles (despite all interests) for preparing or drafting a policy at the federal level. These are:

1. Non infringement on human rights
2. Non adverse effect on the environment
3. A view on sustainable development

The politics of decision making and the recruitment of the right policy instruments are quite fundamental in effecting any positive change. The learnings from the affairs of the Olusegun Obasanjo's administration have been tried by a few successive administrations. However, what worked well for him were his strong military background, and the firm political backing he gave to his recruitees which enabled them function freely in their respective roles.

5.3.6. Interconnections between the various intra-country induced influences

Figure 5.1 shows how the various intra-country induced influences are interconnected. It all starts with recruiting experts with the right competencies. Having *competent* players lead to a better understanding of the *expectations*, which enables more appropriate energy decisions and *legislation* to achieve the desired *future visions*. Achieving the desired future visions requires *recruiting experts* with the right competencies. It is also worth highlighting that whilst figure 5.1 does well in reiterating some of the main links between each of the five intra-country specific themes, it is important to emphasize that all the themes are intimately connected to one another, and hence the actual picture is much messier than what could be inferred from figure 5.1.

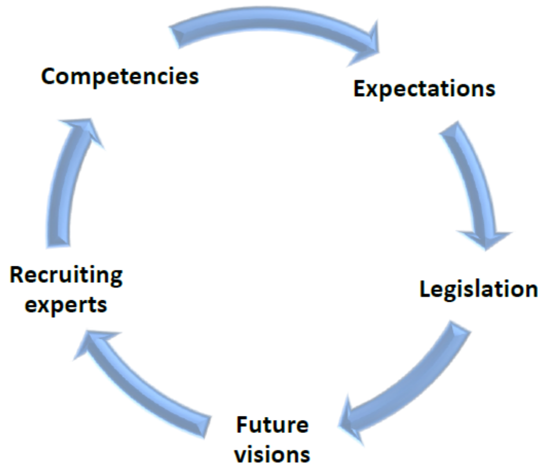

Figure 5.1: The interconnections between the intra-country induced influences

5.4. INTER-COUNTRY INDUCED INFLUENCES ON NIGERIA'S ENERGY INDUSTRY PERFORMANCE

This section presents three major (external) inter-country induced factors influencing the Nigerian energy industry performance:

1. The changing dynamics of international and foreign aid.
2. United Nations Sustainable Development Goals.
3. International agreements and commitments.

These are not the only influences by any means, but did emerge from the analysis as being particularly salient (in terms of impact on Nigerian energy legislation and governance dynamics).

5.4.1. The changing dynamics of international and foreign aid

According to the interviewees, the changing dynamics of international and foreign aid is indirectly affecting the Nigerian energy decision dynamics. Traditionally, international and foreign aid had the sole objective of promoting welfare and economic development in developing countries (Abugre Charles 2010). Most international aid has a grant element. However, the aid landscape is currently undergoing a major international rethink (Carbonnier & Sumner 2012). Some countries are changing their paradigm towards aid and are currently exploring possible alternatives to international aid and cooperation. Indeed, nations and aid givers are re-questioning the aims and scope of aids.in many fora. The global aid landscape is currently undergoing significant changes due to three major factors (Carbonnier & Sumner 2012):

1. *There is a global shift in the geography of poverty*: In the past, the vast majority of the world's poor lived in least developed countries. Today, it has shifted to middle-income countries (Carbonnier 2012). This shift definitely impacts on international aid dynamics as priorities, scope, and scale have to be redefined.
2. *There is a growth of new global aid donors*: The past decades have seen a growth of number of international aid donors, which is creating competition amongst them in addressing development challenges across the world. The rise in number of international aid donors is also impacting on the existing donors redefining their aid priorities and scope (Ranis 2012).
3. *There are redefined international cooperation agenda*: This links to point 2 above. The drive to address issues of global common good, and the quest to fight global and regional common ills, has led to the multiplication of international donors and agencies. These agencies target the promotion and financing of projects that addresses issues of global common good, or fighting common ills, such as, climate change, environmental degradation, global public policies, poverty reduction, and other developmental agenda (World Economic Forum 2010). These developmental agenda are expressed in the United Nations Sustainable Development Goals.

In Nigeria, the changing landscape of energy legislation and governance have been influenced by the presence and actions of some international aid agencies, such as, the World Bank, African Development Bank, the German Development Cooperation

(Deutsche Gesellschaft fur Internationale Zusammenarbeit – GIZ), the United Kingdom Foreign and Commonwealth Office (UK-FCO), among others. They contributed to the implementation of the power sector reforms by setting conditions upon which they can provide aid and investment support in the electricity sector. Indeed, the GIZ have contributed to ensuring that a proper policy framework to encourage investments in large on-grid and off-grid renewables is framed, which is where they intend to channel their aid support (Federal Ministry of Power 2014). Most international aid in the Nigerian energy sector is channelled towards fulfilling some UN Sustainable Development Goals, such as, clean energy and climate action (UNDP 2015).

5.4.2. United Nations Sustainable Development Goals

The interviewees acknowledged the impact of the United Nations Development Programs as a major contributor to the changing dynamics of infrastructure decisions and governance (including energy). They stressed that the Millennium Development Goals of the United Nations shaped government priorities with respect to infrastructure investments and government policies.

The United Nations development targets expressed in the Sustainable Development Goals (SDGs) cannot be achieved without careful consideration of the role of energy. Indeed, all seventeen SDGs have varying degrees of impact on energy. However goals, such as climate action, affordable and clean energy, responsible production and consumption, clean water and sanitation, and sustainable cities and communities, have more direct impact on energy infrastructure decisions and governance at country level (Shittu 2016). Taking action on implementing these goals at country level may require fundamental changes in setting national energy priorities, or redefining the energy mix in order to ensure that a good proportion of the energy, generated and used, comes from clean (renewable) sources (Shittu 2016). Indeed, the newly set SDGs by the United Nations constitute one of the deciding elements being considered by most foreign and international aid donors as a condition for Nigeria (and other nations) to benefit from aid. This is gradually impacting on the landscape of the energy infrastructure and governance nexus in Nigeria, thus, enabling a transition towards implementing actions that addresses the SDGs.

5.4.3. International agreements and commitments

The interviewees acknowledged that a key driver of new thinking and changes in energy infrastructure systems is the international agreements and commitments of the Nigerian government. Some of them include energy/electricity access and a commitment to combat the effects of climate change. As of the time of the interviews, there were already discussions about possible commitment on the Paris climate change convention in 2015. The Paris agreement on climate change is the new global architecture developed to fight climate change and its impact. The interviewees stressed that the Paris agreement on climate change is likely to shape Nigeria's thinking with respect to energy governance. In particular, meeting carbon mitigation targets, and the nationally determined contributions, requires a rethink in the energy governance system and structure.

However, the interviewees further stressed that the most important thing for the Nigerian government is to address electricity access constraints as it is limiting the country's potential for growth in all aspects of its national life.

5.5. DISCUSSIONS, CONCLUSIONS AND POLICY IMPLICATIONS

The case presented in this chapter focussed on the influences that underlie the process and practice of policymaking in relation to Nigerian electricity supply infrastructure provision and energy policy by addressing the second sub-question of this research: - "what exactly constitute the practice of policy making and how has this influenced electricity supply infrastructure and energy policy?" Indeed, guided by the theoretical lenses (of social practices, social psychology and institutional theory) in the analysis presented, the key issues impacting on policy making practices in Nigeria with respect to electricity supply infrastructure are:

Intra-country induced influences, comprising:

- Competencies, - i.e. lack of practical knowledge of energy policy making among current policy makers
- Expectations, - i.e. changing dynamics of past, present and future expectations from the energy industry.
- Legislation, - i.e. the presence of institutionalized (and unwritten) rules/procedures in the energy industry.
- Future visions, - i.e. future visions of the energy industry/energy market.
- Recruiting experts, - i.e. non-systematic way of recruiting new energy and public policy makers into the policy space.

Inter-country induced influences, comprising

- The changing dynamics of international and foreign aid.
- United Nations Sustainable Development Goals.
- International agreements and commitments

The theoretical lenses aided the detection of the findings in different ways. In considering social psychology, the attention was in understanding the role of habits and attitudes of individual actors in the decision making process. Social practices aided the understanding of policy making itself (as a practice) and how carrying out the practice of policy making impacts on the energy supply infrastructure we end up with. Institutional theory was used to ascertain how the institutional dynamics and frameworks impacts on policy decisions on energy infrastructure supply.

With respect to social psychology, the Nigerian case have shown that individual biases and interests impacts on the attitudinal dimensions of the political actors in the policy making process. This has contributed to the case of multiple visions and interests with regards to the future vision of the Nigerian electricity industry. Indeed, these individual biases and interests have also impacted on the (social) practice of policy making itself. In order to ensure personal interests are satisfied in the policy making process on electricity infrastructure, the political actors in Nigeria try to thread the path of tribal, ethnic and (even) religious lines to ensure their interests are met.

Tribal agitations, some of which were results of environmental concerns of energy resource extraction within the geographies where the resources were domicile have resulted in tensions in the decision making spheres. There are examples in the Niger-Delta region of Nigeria where environmental degradation, which is a result of crude-oil spillage, has threatened the livelihood of many communities. An example is the Ogoni land in Rivers State (Manby 2000). Policy makers from that region are under continuous pressure from their communities to ensure that they pursue the interest of the region at the national level at both the national assemblies (Senate and House of Representatives) and the Federal Executive Council. This has had serious implications particularly on the energy legislation dynamics within associated institutions.

These influences on policy making practices affects electricity supply infrastructure in different ways. First, it presents the need for a rethink in electricity planning and governance in addressing future electricity supply needs and associated energy supply infrastructure. Secondly, it presents the need for an understanding of the role of different stakeholders in the electricity supply infrastructure value chain and how each contributes to securing our energy future. This includes the role of those in the downstream oil and gas sector that provides the fuel required by electrical generation plants for electricity generation.

Transition in energy use and energy policy has several consequences such as: economic consequences (Barker 2009; Lutz 2014), which tends to undermine the high costs and low incentives (in the short term) of investments in effecting a shift of energy technology in use; the (apparent) halt in revenues and customers; and social consequences (Stirling 2014), which tend to undermine its impacts on people's lifestyles with respect to appliance usage, transport, industry and commerce, types of houses they live in, income and expenditure, and the environment (Reddy et al. 2000). These consequences are often results of the various influence mechanisms highlighted in section 5.3 (Heldeweg et al. 2015).

The decision making processes and dynamics employed in the governance of energy infrastructure provisions can either foster the provision of the needed infrastructure, following the right energy mix, or increase the energy vulnerability of the given geography or society. The influences highlighted (in sections 5.3 and 5.4) have corresponding consequences across serial interconnected areas particularly in energy planning, energy security, energy pricing (including taxes and tariffs), energy access, and energy market structure governance issues (Joskow 2003). The economics of energy plays a vital role in shaping energy policy which present themselves in the forms of: subsidies and regulations that affect prices of the various forms of energy; market forces; taxes; environmental; and societal costs (Thollander & Palm 2013).

The historical policy decision dynamics have been the major factor that influenced the transition in the Nigerian energy policy, driven by the policy focus within the different stages/phases in energy policy direction. This highlights the increasing role of public institutions and powerful actors (policy makers) in the governance of energy resources and infrastructure provision (Ulli-Beer 2013).

Indeed, this study reveals five major intra-country influences affecting the Nigerian energy industry performance which are: competencies; expectations; legislation; future visions; and recruiting experts. The complexities around policy decisions on energy infrastructure provisions reflect the lack of requisite competencies on the part of energy policy makers, which has contributed greatly to past and present challenges of the Nigerian energy sector. It can be argued that the root cause of some of the intra-country induced influences, such as, competencies and recruiting experts, stems from: nepotism arising from tribalism, favouritism for political party affiliates; and corruption (which seem to be a dominant practice). Indeed, the case of unwritten rules and procedures provides a fertile ground for breeding and institutionalizing corruption in the sector.

The absence of a systematic way of recruiting new players to the policy space poses some concerns on the future governance of the affairs of the energy sector. Considering the growing demand for energy, and the slow pace of energy infrastructure provisions to meet the rising demand, there are concerns if the current policy decision structure is capable of driving the required changes needed to meet both current and future energy demand. This confirms that policy governance structure plays a vital role in energy supply security, which in turn affects other sectors that relies on energy such as residential, transportation, and industry sectors.

Although this chapter focuses on the Nigerian case, there are similarities with other developing African countries with respect to energy governance challenges. The power sector dynamics across many African countries is becoming increasingly complex, which impacts on energy legislation systems (Bellantuono 2010). The socio-technical complexity of energy infrastructure is highly impacted by domestic, national, and regional demand (Houwing et al. 2007). Corruption prominent across most countries in Africa, with around 60% of the African countries classified as being highly corrupt (Bray, 2015).

This study highlights the need for policy makers to have the right competency set. For those that may be deficient, stakeholder engagement and expert consultation provides a platform for a quick win. This could help them to also identify stakeholders they can trust, such that they can, together, make strategic energy plans that can help Nigeria move towards a more desirable energy future. However, there are also social and institutional elements which policy makers need to consider (however competent they are) in order to achieve the target goal, and hence the system in which the policy makers and energy experts are operating within also needs to evolve.

The challenge of unclear policies and some unwritten rules poses a business risk to current and future investors in the sector. However, the current business opportunities far outweigh the current regulatory challenges as the Nigerian energy market is huge and very much untapped. This study brings further questions to the fore that needs to be explored by further research such as: the actual linkages and impacts between energy policy governance and energy infrastructure provision; as well as the (un)intended consequences of policy decision process/dynamics on the energy industry.

Finally, there is a need for the Nigerian government to *define the energy infrastructure and governance nexus* in order to limit the effects of unintended consequences, as a country's total infrastructure stocks (including energy) also contributes to its GDP. This means setting clear rules and defining (technical and policy) regulations for the effective governance of the (local) energy industry and energy infrastructure provisions. This can be done by understanding and influencing, through regulations, institutional rules that govern the workings of institutional actors in energy supply infrastructure provision within institutional and structural frameworks.

Chapter 6 THE ROLE OF POLICY MAKERS AND INSTITUTIONS IN THE ENERGY SECTOR: THE CASE OF ENERGY INFRASTRUCTURE GOVERNANCE IN NIGERIA.

This chapter, with respect to critical realism, focusses on uncovering the 'empirical layer', i.e., those things that are observable. This chapter focussed on addressing the third sub-question: "what are the linkages and consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision? Table 6.1 presents a summary of the sub-question being addressed, the guiding theories and the guiding questions which serve as point of departure in addressing the chapter aim.

Table 6.1: Summary of chapter aim and guiding theories

Sub-questions	**Guiding theories**	**Guiding question (point of departure).**
What are the linkages and consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision?	Social practices	How do government intervene in energy infrastructure matters?
	Institutions	What are the consequences of the institutional structures on energy?

6.1. INTRODUCTION

Energy is important today, and will still remain important going into the future. Energy is still what binds a lot of communities and nations, particularly through country level energy strategies (Konadu et al. 2015). A great deal of emphasis in many parts of the world still remains securing energy supply (Leiby 2007; IEA 2012a). For some countries, it is about reducing dependence on imports and looking for new energy sources, routes and suppliers that make a better economic sense (Greenpeace International 2014). For others, it is about having a strong economy, while minimizing any adverse effect on the climate, driving job creation, and having a gradual transformation of the entire transport system from predominantly fossil fuel based, among other sectors (Dineen et al. 2014). For some countries, the focus is on having a fully integrated internal energy market, without regulatory or technical barriers, in order to freely compete and provide the best energy prices that can drive growth in the economy (Navarro & Sambodo 2013).

Over time, the increasing role of governments and public institutions in many countries and regions has been felt through more regulation of the activities in the energy industry (Scott et al. 2011; IEA 2014a). This increased regulation of the energy industry poses some questions. How does the policy decision process affect the governance of electricity infrastructure provision? How has historical decisions affected electricity infrastructure provision? What are the linkages between the policy decision process and the governance of electricity infrastructure? What are the (intended and unintended) consequences of the policy decision process? Answering some of these questions is important in better understanding the consequences of the policy decision process and how to mitigate the adverse and unintended effects of such decisions. This is needed because knowledge of the effects of the policy decisions and governance process helps in ensuring that decisions made have limited unintended consequences (Kander 2000).

Based on documentary data evidences and semi-structured interviews conducted, this chapter (using Nigeria as a case study) focused on exploring the linkages and consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision.

In addressing the third sub-question of this research, this chapter highlights the methodological considerations (section 6.2). It highlights the linkages between policy making and institutions in the governance of energy infrastructure provision, and concludes by highlighting the three major unintended consequences of the policy decision processes and institutions (section 6.3). In this chapter, the term energy is also taken to mean electricity, unless otherwise stated.

6.1.1. The policy cycle

There are six important stages that contribute to policy formulation as highlighted in figure 6.1 (Climate and Development Knowldge Network (CDKN) 2015; Krauss 1989). These six stages that contribute to policy cycle are:

1. *Issue awareness stage* – The emphasis is on gathering information about the key that may necessitate the need and development of a policy (e.g. energy access, carbon emission). The potential barriers and opportunities are identified, collected and analyzed at this stage.
2. *Problem definition stage* – The implications of potential barriers and problems are identified at this stage, e.g. the problems relating to energy infrastructure provision.
3. *Identification of options stage* – The possible consequences of the potential policy options is assessed. An example could be the consequences of decentralizing electrical power generation and its impact at the socio-economic, environmental and technical levels.
4. *Policy selection stage* – A choice is made regarding the preferred policy is made, which builds on the previous stages' understanding of the associated problems and their implications. An example could be choosing an energy generation decentralization policy that addresses the problem of energy access, while improving energy security and reducing vulnerability.
5. *Policy implementation stage* – There is a translation of policy into action. This essentially means the adoption of a particular policy after all the necessary deliberations by concerned stakeholders.

6. *Policy evaluation stage* – Evaluation, monitoring, and tracking of the chosen policy is done in order to ascertain the progress. The evaluation, monitoring and tracking process also helps in measuring the awareness level. Constant evaluation and monitoring on energy access helps in determining the number of persons that now have access to energy after a given period, and also help in ascertaining what amount of energy infrastructure is required to bridge the identified gap in energy infrastructure deficit to address energy access issues.

Figure 6.1: The various stages of the policy cycle (Source: Climate Planning (2016))

The policy cycle have been introduced in this section as a template of what constitutes a good policy formulation process. I have raised the issue of the policy cycle here because (as earlier argued from the findings of chapter 5), it is generally believed that, within the Nigerian context, there is no systematic way of recruiting people into the energy policy space, which inherently impacts on energy legislation dynamics and the policy making process. How closely is this cycle followed in the context of the provision of energy infrastructure in Nigeria?

6.2. MATERIALS AND METHODS

In investigating the linkages and consequences of the policy decision processes and institutions (Scott et al. 2011) within the Nigerian context, a mixture of documentary evidences and semi-structured interviews were used. These were the same interviews presented in chapter 3. Some additional documents were collected to further understand the empirical aspects of this research. Indeed, with respect to critical realism, this chapter focused on presenting the ‘empirical layer’, i.e., those observable aspects of the reality under study.

In addressing the chapter aim, the following theoretical lenses were used:

1. *Institutional theory:* to ascertain how ‘institutional dynamics’ in formulating and enforcing regulations impact on energy supply infrastructure
2. *Social practices*: to ascertain how the ‘practice of policy formulation and enforcement’ impact on energy supply infrastructure

These two lenses were useful because institutional theory helps in understanding the institutional dynamics of electricity infrastructure governance while social practices helps in understanding the role of the actors and how the practice of policy making and governance impact on institutional workings and dynamics in relation to electricity infrastructure supply and governance. Indeed, these two theoretical lenses were also useful in ascertaining the unintended consequences of the policy process within the Nigerian context.

<u>Why collect additional documents?</u>

During the interviews, some of the interviewees made reference to some policy documents that were in the process of consideration for review, which could impact on changes in energy infrastructure supply and governance (including electricity). As a result of this, more documents from some regulatory agencies were collected to ascertain the linkages between policy making and energy infrastructure supply. The following agencies were sources of further policy/regulatory documents:

- Nigerian Electricity Regulatory Commission (NERC)

- Rural Electrification Agency of Nigeria (REA)
- Electricity Services Management Limited (EMSL) of Nigeria
- Energy Commission of Nigeria (ECN)
- Nigerian National Petroleum Corporation (NNPC)
- Department of Petroleum Resources (DPR)

The same analysis of document content as highlighted in chapter 3 was done to ascertain the linkages between policy decisions and energy infrastructure supply (following indications as per interviews conducted). The following select documents (which were generated based on decisions and rulings from the policy process) were analyzed for the purpose of understanding how policies and policy making links with energy/electricity infrastructure supply.

- Handbook on application for licenses (and related licensing/permits forms) (NERC 2010)
- Nigerian electricity smart metering regulations (NERC 2015)
- Nigerian electricity supply and installation standards regulations
- Regulations on embedded generation
- Regulations on national content development in the power sector.
- Regulations on procedure for electricity tariff reviews in the Nigerian electricity supply industry
- Regulation for captive power generation
- National energy policy document
- Guidelines and requirements for oil and gas industry service permit
- Requirements for obtaining offshore safety permits
- Guidelines for the importation of petroleum products into Nigeria
- Guidelines for bunkering operations in Nigeria
- Statutory guidelines for the operation of coastal vessels

These documents were analyzed to ascertain those salient areas where policy making influence energy supply infrastructure. Indeed, the themes (linkages) were drawn primarily from policy documents and associated literature. Additional interview analysis was performed through the use of a top-down (deductive) approach in the analysis of the same interview data used as the basis for analysis in chapter 5.

In chapter 5, I have adopted the use of the bottom-up (inductive) approach for the Interview data analysis to generate the themes. The bottom-up approach was such that ideas were generated and controlled from a lower level of hierarchy and then progressed upwards to form categories and themes. However, in this chapter, a top-down analysis approach was used. Top-down analysis is an approach in which an idea is controlled from a high-level standpoint. It starts with a general idea, while details are gradually added as we go down the hierarchy. The general ideas were themes generated from the policy related documents, which were then supported by evidences from the interview notes.

6.3. FINDINGS

In sub-section 6.1.1, the policy cycle was presented as an ideal model for the policy formulation process. In addressing the third sub-aim of this thesis, this study also tries to ascertain if the policy cycle model (proposed as an ideal policy formulation model) is followed in practice within the Nigerian policy context.

This section presents two broad findings, based on the interviews and documentary analysis, of this study. Section 6.3.1 presents the linkages between the policy making processes and institutions in the governance of electricity supply infrastructure while section 6.3.2 presents the unintended consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision.

<u>6.3.1.</u> Linkages between policy making processes and institutions in the governance of electricity supply infrastructure.

In investigating the linkages (and indeed influences) between energy infrastructure provision and policy making within the Nigerian context, the policy document analysis (supported by the interviews) revealed three major points of departure through which policy makers and policy institutions exert influence on energy infrastructure supply. These are:

1. Issuance of licenses/permits
2. Regulations
3. Granting access (to historical data).

Permitting involves the granting of an official permission or authoritative certificate for an entity to perform certain actions (Vann 2012). Energy regulations entail the rules governing the extraction, production, sale and use of energy (Schwartz 2012). Granting access to historical data on the sector's activities can help investors shape their business expectations and ascertain some of the embedded business risks, which might still be unclear. However, how important are permits and regulations in the electricity industry and the energy market (Schultz & Sharpe 2014)?

Within the Nigerian context permitting and licensing provides the entry points for participation in the energy industry. The federal ministry of petroleum resources oversees the affairs of the Nigerian oil and gas industry through the Department for Petroleum Resources (DPR). The DPR also oversees the affairs of the Nigerian Nuclear Regulatory Authority (NNRA), responsible for the development and regulation of nuclear power in Nigeria. The DPR has the statutory function of processing and granting approvals, licenses and permits across the entire oil and gas value chain. This ranges from exploration and production permits to retailing activities of oil and gas by-products. Besides granting permits, the DPR has responsibility for compliance to regulations, guidelines and petroleum laws within the entire oil and gas spectrum in Nigeria. The role of the DPR is important within the Nigerian context as most electrical generation plants depend on the activities of the downstream oil and gas sector for fuels required to power the generation plants.

Indeed there is need for regulation and competition in energy markets which assures both the freedom of enterprise and the freedom of choice of the consumers (European Commission 2016). It grants the benefits of efficiency that comes from the choice of available options, and provides an ideal environment for promoting innovation (Schultz & Sharpe 2014). It is argued that there are no fair competitions in a market where there are no rules, which is why regulations are promulgated to govern the affairs of a sector or market. Since competition does not happen by itself, competition laws and policies are promulgated in order to ensure that entities do not develop unfair market power, which restricts competition (Koyama 2013). Laws and institutions are set up not only to prevent cases of market power, but also to punish the abuse of such when it arises (Office of Fair Trading 2004).

Additionally the Nigerian electricity and gas market, in generic terms, has been traditionally designed to be monopolistic in nature (Kim & Horn 1999). This has been supported by the argument that it is better for a single entity to take responsibility for the entire value chain of the energy supply and electricity infrastructure system so as to ensure the proper handling of technical, efficiency and interconnection issues. This is one of the main contributors to natural monopoly in the Nigerian energy (and particularly electricity) market experienced for a long time, until 2005 when the new roadmap on electricity reforms paved the way for future private sector participation.

It has been argued that in the electricity supply industry, it is possible to maintain a unique network with several companies in the value chain of electricity and gas generation, extraction, production and sales (Kim & Horn 1999). This is only possible however, for those companies which already have access to essential facilities in the network, as defined under certain conditions that are detailed in the regulations.

Taking a leaf from the experiences of some developed economies in different parts of the world, regulatory institutions governing the different parts of the energy sector have either been transformed, or new ones set up (Biermann et al. 2012). These institutions are generally considered as independent with respect to the regulated companies, and have to be protected from excessive influence of the regulated companies on their regulator (Mitchell et al. 2015). However, there might be cases where the government owns majority shares of large energy companies, as is the case of Nigeria. What should happen in principle is that the regulator should be independent of the government, however, in practical terms, it is quite difficult not to have some level of influence (Cunningham 2015). Table 6.2 presents a summary of the areas of influence by policy making/regulatory institutions, where policy makers influence decisions through policy/regulatory interventions in primary energy resource extraction and development within the Nigerian context as obtained from the documentary evidences (regulatory guidelines) and interviews conducted.

Table 6.2: Shows the linkages/areas of policy and regulatory interventions in the extraction and development of energy resource infrastructure

		Energy resource (extraction) and infrastructure development			
		Oil & Gas	**Coal**	**Gas & electricity**	**Nuclear**
Areas of policy and regulatory int6erventions	**Issuance of licenses**	Licensing participants involved in natural gas and crude oil exploration and production	Issuing licenses for coal exploration and extraction.	Licensing of participants and players in the electricity and gas market. .	Providing licenses and permits to market players.
	Regulations	Regulations with respect to: New oil and gas field development and pipeline activities Environmental aspects of oil and gas extraction, production and decommissioning.	Managing environmental effects of historical mining activities such as contaminated water from coal mines.	Providing the required framework for regulation of the electricity and gas market. Appointing members of the various national public iinstitutions that set the strategy for the development and provision of various infrastructure, such as: Federal Ministry of Power (FMP); National Electricity Regulatory Commission (NERC); Nigerian National Petroleum Corporation (NNPC); Standards Organization of Nigeria (SON); and other relevant stakeholders.	Providing regulatory framework and regulations for licensing and permitting.
	Granting Access	Granting access to oil and gas exploration and production data.	Access to mining information/data.	Access to historical and resource data, such as: quantities and location of gas reserves, water resources, etc.	Access to natural resource data such as location and quantity of uranium reserves.

6.3.2. Governing electricity supply infrastructure: the unintended consequences of policy decision processes and institutions.

The governance of energy infrastructure change involves different stakeholders (energy consumers, industry, residential, energy investors, policy makers, etc.) who are important actors in influencing the kind of decisions made and the energy infrastructure we subsequently end up with (Florini & Sovacool 2009). However, the dynamics and complexities governing energy and electricity infrastructure provisions leads to many stakeholders employing different lobbying mechanisms to make their issue position known, prioritized and then adopted (Beach & Keast 2010). Satisfying the interests of different stakeholders in the governance of electricity infrastructure provisions necessarily leads to some unintended consequences (Giddens 1991). Following the documents analysis and interviews conducted, three salient unintended consequences of the policy decision dynamics were evident in the governance of electricity infrastructure provision in Nigeria. These are:

1. Increased opportunities for, and incidence of, corruption in over-centralized governance.
2. Economic delusion
3. Energy demand driven more by export needs rather than local consumption.

The following sub-sections further delve into the details of the aforementioned unintended consequences.

<u>Increased opportunities for, and incidence of, corruption in over-centralized governance.</u>

In the literature review chapter of this thesis (chapter 2), a section was introduced (separate from the five theoretical perspectives) which covered ‘energy, corruption and the black economy’, In that section, the three notable types of corruption within a democratic setting and their relation to energy infrastructure supply was presented. Indeed, grand corruption, legislative corruption and bureaucratic corruption are three types of corruption that are generally believed to be evident in the broad spectrum of the energy industry in Nigeria (particularly in the oil and gas sub sector).

Most literatures focused on studies on corruption within the oil and gas sub-sector with very few studies linking corruption with the electricity sub-sector. This is so because lots of evidences of corruption within the oil and gas sub-sector have been collected over time. How does the regulatory and governance landscape impact on electricity supply infrastructure? Are there unintended consequences? This section presents evidences from interviews and archives on how opportunities for corruption in the electricity sub-sector increases in over-centralized system of governance.

Prior to independence in 1960, Nigeria existed as regions with regional governments. Policy decisions were taken at regional, as well as national level. The decision making process at that point was decentralized. This meant that the various regional governments could draw up and implement policies on different aspects of life in society, including resource extraction and production, while they made some contribution to the central government. The regional system of government created some sort of healthy competition among the regions, which aided the discovery and development of (mineral and energy) resources in the different regions. However, with the advent of crude oil and military rule in the 1970s, the governance structure was upturned by the military. The control and governance of (mineral, energy and other) resources, including strategic planning, were centralized and controlled by the central government. This means that all the prospects and challenges of the different regions were now centralized, that the central government decides who should have what, and that many decisions (including social and economic) were heavily politicized. Indeed, this has also affected the way in which energy infrastructure is governed in Nigeria. From the findings of the interviews, it is argued that the military upturned things to their favour in order to have full control of the country's resources (particularly crude oil).

> *Nigeria's centralized system of decision making was driven by the quest for political power, while political power was driven by corruption as those in the political space were greatly enriched by the system.*
>
> (Extract from interview notes)

The centralized system of decision-making has become deeply embedded in the Nigerian political culture. Despite the apparent collapse of military rule, there is still a well-entrenched centralized decision making culture within the democratic setting (Zábojník 2002). This is because many political players within the current democratic setting were either once in the military, or served under the military rule where this culture has been historically entrenched. However, how did corruption come into the scene? (Amundsen 1999)

Opportunities for corruption emerged from certain governance and institutional structures and practices, rather than being intentionally designed (Marcel & Heller 2012). Before the privatization and decentralization of the electrical power sector, the government had been responsible for both provision of new electricity supply infrastructure, as well as the maintenance of existing electricity infrastructure. The Nigerian Electric Power Authority (NEPA), which later metamorphosed to the Power Holding Company of Nigeria (PHCN), an institution of the federal government of Nigeria, had the responsibility of managing every aspect of the electrical power network from the generation plants, to transmission and distribution network infrastructure (Sambo 2008).

Like every other government institution, the NEPA prepares a plan for overhaul, upgrade and maintenance of some targeted aspects of the electrical network infrastructure each year (Hemme 2015). However, the culture has been that, for example, if the NEPA requires $3 million for a major overhaul of a power plant, the government may decide to release $1.5 million for the project, and inform the public that funds have been released for the required overhauls, as such; there should be improved electricity supply.

> *…when the NEPA brings to the fore (mostly in writing) that the released funds cannot complete an overhaul, the typical response is “that’s what*

we have; you have to use it as that is what our budget can accommodate".

(Extract from interview notes).

As such, the NEPA is left with the option of having a make-shift maintenance arrangement (which cost much less than the funds released) rather than have a complete overhaul. This can result in more funds in the possession of those responsible to do the supposed 'overhaul' which ends up as a 'routine maintenance service'; and the extra funds, many a times, do not manage to find their way back to the government treasury (World Bank 2009). This is one of the reasons why fighting corruption in the Nigerian electricity sector still proves very difficult (World Bank 2009; Ruth 2002).

<u>Economic delusion</u>

A major unintended consequence of the policy decision dynamics in the electricity sub-sector is economic delusion (Kumar 2014). Economic delusion is simply the falsity or deceit that the economy is thriving and waxing strong whereas the reverse is the case (Buddhist Publication Society. 2009). It is believed that Nigeria saw an economic boom in the 1970s particularly as it relates to industrialization and investment in agricultural processing plants. However, this was not the case as in reality; Nigeria was de-industrializing during that period but what was responsible for this?

Economic delusion was caused by the false perception of economic growth. In the 1970s, Nigeria started experiencing growth in oil and gas production and export, while there was a simultaneous decline in manufacturing activities. The focus on developing the oil industry due to its huge prospects for increased income led to less attention being given to the manufacturing and industrial sectors. This occurred through non judicious implementation of established energy policies targeted at aiding industrialization. Thus, growth of established industries was restricted by limited available (electrical) energy supplies.

From the late 1920s, future projections of electricity demand were made with the aim of ensuring that electricity infrastructure was provided to aid future industrialization prospects, and in particular, to support the growth of the agro-allied and food processing industries (Isaksson 2009). This future projections led to the establishment of the then Nigerian Government Electricity Undertaking (NGEU). The NGEU was set up in 1946 to make a concrete plan of increasing electricity supply infrastructure to meet future demand of electricity for both residential and industrial use. This led to the 10-year plan covering a period of 1946 – 1956 which was aimed at increasing the electricity supply by around 200%. This plan led to massive industrialization from the 1950s as this was the period that many investors in the agro-allied and food processing sector established presence and set up their factories in Nigeria. Thus, by 1971, there were more than 2000 industries in Nigeria involved in food processing/agro-allied manufacturing (Francis Jackel 1997a).

In the 1970s, the actual electricity infrastructure provision was much less than the previously estimated projections (Sambo 2008). This led to a situation where the growth of many of the industries was limited by the amount of available electrical energy (Stern & Kander 2012). Expansion and growth became impossible for many of the manufacturing industries while they were left with the option of growing at the pace with which electrical energy infrastructure were provided. Thus, the inadequate provision and supply of electrical energy infrastructure limited the growth of the manufacturing sector, which then worsened, through de-industrialization, as all future growth in industrialization activities was halted by the non-provision of electrical supply infrastructure (Stern 2010). It is a popular belief that the 1970s was the real industrial economic boom period for Nigeria; however, it was actually the period of industrial decline.

<u>Energy demand driven more by export need and not local consumption.</u>

This section presents the key driver of energy demand (within the Nigerian context) as evidenced from the interviews and documents analyzed. Figure 6.2 presents the Nigerian energy flow, which shows the linkages between primary energy resources and various end-use applications in Nigeria. The figure shows petroleum (crude oil) as the most extracted energy resource (African Development Bank & African Union 2009). However, much of it is exported. The second most produced form of energy source is the biomass, which is also the most commonly used, providing energy services in majority of homes particularly in rural areas. Natural gas is used more for electricity generation (both for industry and large power plants). Why is wind, solar, geothermal, and nuclear sources not explored? What policy contexts or energy market structure influenced the use and misuse of various energy resources? What policy contexts influenced the kind of energy infrastructure we ended up with? Answers to these questions can be better understood by having a better appreciation of the historical contexts of the various energy (infrastructure) sources (as outlined in chapter 4).

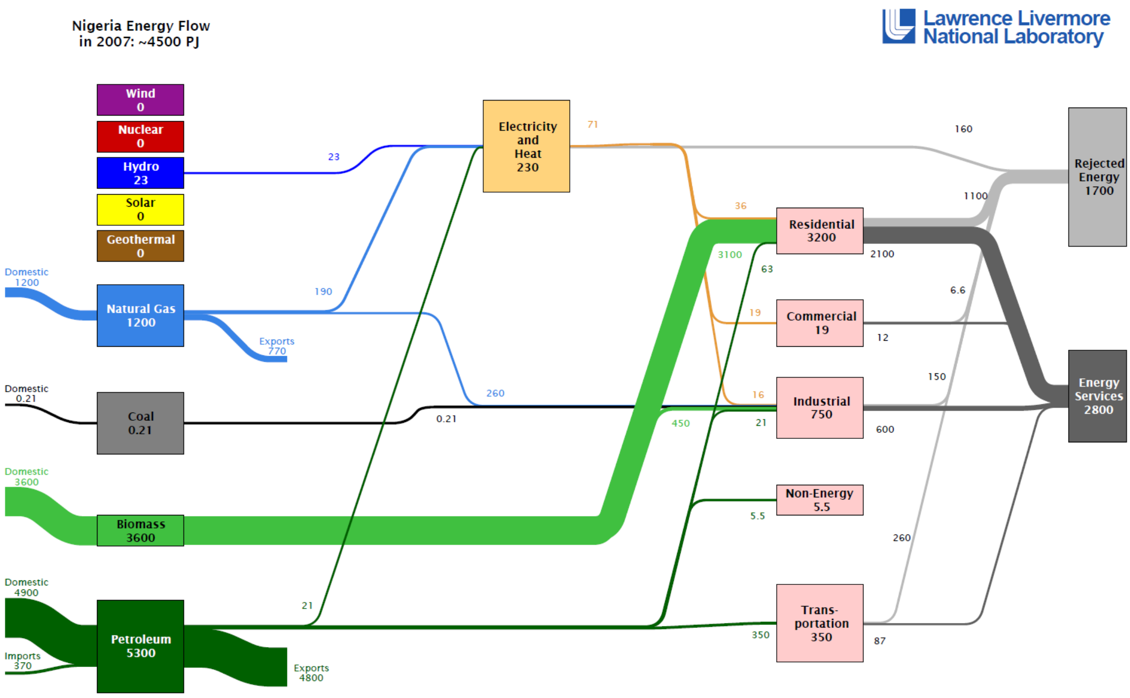

Figure 6.2 The Nigerian energy flow (Smith et al. 2011. Pg. 90).

The interviews revealed that it was the initial provision of energy and electricity supply infrastructure that led to the uncontrolled growth in demand for energy. From Figure 6.2 (showing the Nigerian energy flow), the following are quite obvious - which seem to conform to some of the findings of the interviews:

1. There is a large demand for petroleum (crude oil) and natural gas. However, a large part of the extracted crude oil and natural gas are exported. This signifies that the energy supply infrastructure provided in Nigeria was not meant to satisfy only the local demand, but also to meet the demands of the international market.
2. The residential sector is the largest consumer of energy resources in Nigeria with a large part of these resources coming from traditional biomass used more for energy services within the homes. A large part of this energy, however, is being wasted through emissions and inefficient equipment and appliances.
3. Hydropower, natural gas and crude oil (petroleum) are the three dominant resources used for electricity generation, with a potential for natural gas growing geometrically due to the policy direction of the Nigerian government to use more natural gas for electricity generation.
4. The industrial and commercial sectors combined, use far less energy resources in comparison with the residential sector.

6.4. DISCUSSION – LINKING FINDINGS TO THE POLICY CYCLE

There is a traditional notion of institutional independence which most likely underestimates policy makers' capacity to (in)directly shape energy policy. This traditional notion tends to overlook why lawmakers might want to shape energy policy. It is important, when analyzing the works of international governmental organizations, not only to look at rational calculations but also the pre-existing values and norms that informs the workings of those institutions. It is also important to understand the mind-set of those who have to design those institutional workings. An approach that takes into consideration history, context and values are important in creating legitimacy and efficiency in the internal workings of institutions.

Under ideal situations, the policy cycle described in section 6.1.1 provides a template for the effective formulation of policies. Arguably, following the policy cycle template is meant to limit cases of unintended consequences. However, the study of the Nigerian case evidences that the policy cycle template is barely followed. From the interviews and analyses of policy documents (as evidenced in the findings) one gets the impression that some policies erupted due to the pressing need to address a specific challenge, such as electricity supply. The interaction that should happen between the various stages in the policy cycle barely happens in Nigeria. This is what leads to stakeholder conflicts since some of them are not consulted (or given opportunities to make inputs) in the policy formulation process. Indeed, not following the policy cycle provides incentives for corruption as evidenced in the findings.

A major consequence of not following the policy cycle process is the lack of transparency in the extractive sector (including energy), which raises the question of the governance model for natural resources (Lehmann 2015). Indeed, within the Nigerian context, the quality of those involved in policy making has greatly improved due to improvements in education. However, this has not translated well in the governance of energy infrastructure provisions.

Figure 6.3 shows what the actual cycle looks like within the Nigerian context. It is not an actual cycle as most of the individual stages are handled independent of the other in the policy formulation process. This is what results to unintended consequences, which often can be traced to lack of interaction and stakeholder engagement in the policy development process.

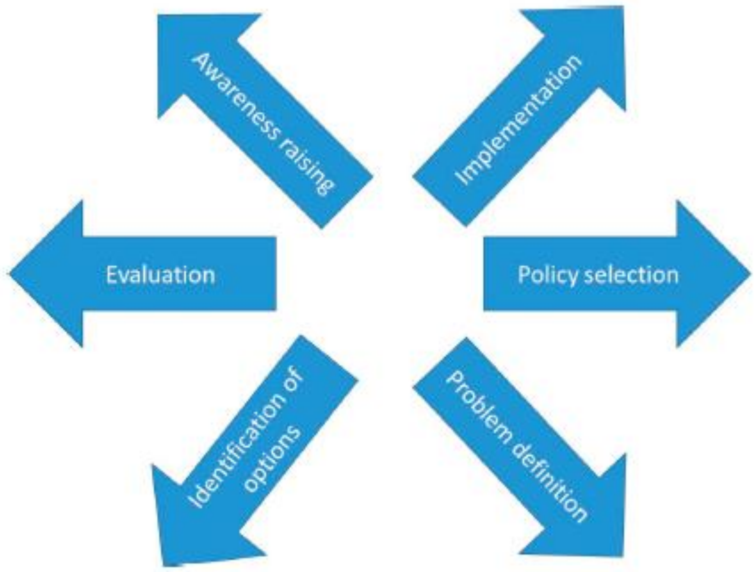

Figure 6.3: the actual policy cycle stages which is not a cycle

To improve decision making, it might be appropriate to provide decision makers with an understanding of specialized knowledge and expertise that can assist them in making intelligent decisions among possible alternatives.

6.5. CONCLUSIONS

This chapter focused on investigating the linkages and consequences of the policy making process dynamics and energy infrastructure provisions in the context of Nigeria. The study, in addressing the third sub-question of this research, reveals that the linkages (and therefore, influences) shaping electricity infrastructure supply in connection with the policy making process in Nigeria are: permitting/issuance of licenses; regulations; and granting access (particularly to historical data). It also reveals the unintended consequences of the policy making process dynamics as: increased opportunities for, and incidence of, corruption in over-centralized governance; economic delusion; and energy demand driven more by export need and not local consumption.

Following the findings of this chapter, it is crucial for the Nigerian government to define the energy infrastructure and governance nexus in order to limit the effects of unintended consequences. It is also crucial that the governance and provision of energy supply infrastructure be decentralized and polycentric. This will enable different tiers of government to take decisions and implement their energy infrastructure choices.

The chapter reinforces the need for policy makers and regulatory institutions to stay focused and concentrate on the task that is their mission. Policy makers have to be accountable to government by providing a clear description of the results of their activities which should be consistent with the directives that set up such institutions in order to limit the cases of unintended consequences. Regulations are meant to be built to create a stable environment to facilitate investment and proper management of the companies that are players in the energy market.

Stakeholder engagement is important in the policy formulation process that leads to energy infrastructure choices. This provides an avenue for interaction, learning and mutual decisions on energy supply infrastructure, thus, encouraging the use of the policy cycle template in decision making. This indeed will help ensure stakeholder buying in in the final policy that is then promulgated.

Part IV: Discussions

Chapter 7 DISCUSSIONS

This chapter discusses some of the findings from the three preceding results chapters (4 - 6). It links the finding back to the central research question by presenting the (policy) influences on energy supply infrastructure, thus, addressing the central research question. It starts by briefly summarizing the findings of the preceding results chapters, addressing each research sub-question (section 7.1). In addressing the central question of this thesis, the policy influences on Nigeria's electricity supply infrastructure were also presented (section 7.2). In section 7.3, a comparison of the different influences are presented to uncover the cross cutting themes while linking them back to existing literature. In section 7.4, I discuss path dependency and systems lock-in and their effects on the Nigerian energy transitions, while I finish by presenting some of the key learnings from this research (section 7.5). A short summary of the conclusions from the findings are presented in section 7.6.

7.1 SUMMARY OF RESULT CHAPTERS FINDINGS

This section begins with a summary of the main findings with respect to the three sub-aims of this thesis, which were the central focus of the discussions in chapters 4 – 6. The following sections summarize the findings of each results chapter.

7.1.1 The evolution of energy infrastructure provision in Nigeria.

In chapter 4, the Nigerian historical energy transition with respect to the evolution of energy infrastructure provisions was investigated. The dominant drivers of electricity infrastructure supply within each energy era in Nigeria were also investigated. These drivers, which comprises technological interventions and pathways, institutional interventions, social practices and public values, energy resources and other economic considerations, played an important role in the governance and provision of historical electricity supply infrastructure in Nigeria.

In chapter 4, it was discovered that a complex connection between resources, trade, institutions and political structures existed. These complexities were further aggravated by the creation of several decision making institutions within each energy era, as well as the policy direction of the government. Decisions by these (public) institutions led to serial changes, and eventual transition, in the use of different primary energy resources (coal, crude oil, natural gas) to satisfy the growing demand for energy. It also reveals that the increased use of primary energy resources were primarily influenced by the availability of those resources, while the growing demand served as a secondary reason.

Indeed, these institutions were shaped both by energy needs and by significant external socio-political events which were unique at certain points of Nigeria's history. Such events certainly represent key moments of societal - and consequently, infrastructural - change. For example, the First World War impacted on the sourcing of spare parts for the first set of electrical power plants. Some power plants needed to be cannibalized to keep others operational due to difficulty in getting spare parts during the war period. Moreover, during the Second World War, coal mining activities reduced, which led to the reduced use of coal for electricity generation during the war period.

These findings reinforce the need for sustained investment and leadership by public (government) institutions (particularly in addressing energy access issues), as well as increased partnership between public institutions, industry and private investors in the provision of electricity supply infrastructure. Governments, through public institutions, need to provide economic incentives to increase energy infrastructure provision through promulgation of policies to aid private investment.

<u>7.1.2</u> Policy making and energy infrastructure change in the electricity sector.

In chapter 5, policy making and energy infrastructure change in the electricity sub-sector was investigated. The emphasis was on understanding the policy influences on electricity supply infrastructure and governance in Nigeria and their corresponding impacts.

The chapter reveals five major themes as intra-country induced influences impacting on Nigeria's electricity industry performance, which are: competencies, expectations, legislation, future visions and recruiting experts. It also reveals that the changing nature of international and foreign aid, United Nations Sustainable Development Goals and the dynamics of international agreements and commitments serve as salient inter-country induced influences on the Nigerian electricity industry performance. The lack of practical requisite knowledge and competencies by policy makers have contributed to the increasing complexities around policy decisions on energy infrastructure provision. The smooth future governance of the affairs of the energy sector is being threatened by the absence of a systematic way of recruiting new players to the policy space. This research also reveals that there are concerns about the current policy decision structure, and its capability of driving required changes needed to meet both current and future energy demand, especially considering the slow pace of energy infrastructure provision.

Unclear policies and unwritten rules pose business risk for current and future investors in the Nigerian energy sector. However, the chapter also reveals that the current business opportunities far outweigh the regulatory challenges since the Nigerian energy market is huge and still very much untapped.

The changing aid dynamics has also impacted greatly on electricity infrastructure provisions in Nigeria. Most aid donors now tie their aid donations to specific development outcomes and objectives, International aid no longer have a grant element as they used to be in the past. This is impacting on energy legislation and governance since the interests of some of these organizations needs to be addressed. The United Nations Sustainable Development Goals also puts pressure on the Nigerian government to address issues of energy access and better livelihood through provision of more electricity infrastructure to aid growth and development.

7.1.3 Linkages and unintended consequences of energy policy governance

In chapter 6, the linkages and consequences of the policy processes with respect to the Nigerian electricity infrastructure governance were presented. The chapter also focused on highlighting the unintended consequences of past policy processes relating to electricity governance.

The chapter reveals that the interaction between the policy process and electricity infrastructure provision occur at three major points of departure: permitting/issuance of licenses; regulations; and granting access (particularly to historical data). The chapter also reveals three major unintended consequences of the policy processes and institutions as: opportunities for, and incidence of, corruption in over-centralized governance; economic delusion; and uncontrolled growth in energy demand driven more by export, rather than local consumption needs. Whilst the chapter reiterates the role of regulations as a useful tool in creating a stable environment to facilitate investment and proper management of the companies in the energy market, it does emphasize the need to be cautious (due to unintended consequences, for instance).

Table 7.1 briefly summarizes the findings of the individual chapters (sub-aims), in the context of how they then crucially feed into the overarching conclusions of this thesis as a whole (thesis' central research question).

Table 7.1. Summary of research findings from result chapters

	Central highlights and conclusions
Conclusions from sub-aim 1	- There is a complex connection between resources, trade, institutions, and political structures, in relation with energy infrastructure provision - Five major drivers which are: technological interventions and pathways, institutional interventions, social practices and public values, energy resources; and other economic considerations have influenced Nigeria's historical energy transitions: - The Nigerian energy transitions was influenced more by energy resource availability, and economics of extraction of primary energy resources - Sustained public investment and leadership by public government institutions is still required in order to ensure the adequate provision of the needed energy infrastructure
Conclusions from sub-aim 2	- Five major intra-country induced influences affecting the Nigerian energy and electricity industry performance are issues related to: competencies; expectations; legislation; future visions; and recruiting experts - The changing dynamics of foreign aid, UN Sustainable Development Goals and the dynamics of international agreements and commitments serve as dominant inter-country induced influences. - The absence of a systematic way of recruiting new players to the policy space poses some concerns on the future governance of the affairs of the electricity sector in particular, and the energy sector in general. - Increasing complexities on energy infrastructure policy decisions reflects the lack of requisite knowledge and competencies on the part of energy policy makers, which have contributed greatly to the historical decay of the Nigerian energy sector. - Policy governance structure plays a vital role in energy supply security, which in turn affects other sectors that relies on energy, such as residential, transport, and industry sectors.
Conclusions from sub-aim 3	- The linkages between policy making and electricity infrastructure provisions in Nigeria are evident through three main points of departure: permitting/issuance of licenses; regulations; and granting access (particularly to historical data). - Some unintended consequences of the policy making processes within institutional frameworks are: opportunity for corruption in over-centralized governance; economic delusion and uncontrolled growth in energy demand driven more by export and not local consumption.

7.2. POLICY INFLUENCES ON ELECTRICITY SUPPLY INFRASTRUCTURE

This section attempts to address the central research question: ‘what are the policy influences on electricity supply infrastructure?’ This section presents those influences as revealed in this research.

Within the Nigerian context, there are three broad (policy) influences on electricity supply infrastructure in Nigeria (as shown in figure 7.1). These influences that have impacted on changes in electricity (and indeed energy) systems, as revealed in this research are comprised of three broad drivers, which are:

1. Past drivers
2. Policy drivers
3. Institutional drivers

The past drivers are characterized by those factors that have impacted on historical changes in energy infrastructure supply systems. Within the Nigerian context, these factors comprise five important salient elements, which are: policy/institutional interventions; technological interventions and energy technology pathways; social (societal) practices and public values for energy; available energy resource options; and economic considerations. These five salient elements impacted on Nigeria’s energy transition.

The policy drivers are characterized by those factors that influence the decision making process, such as knowledge and legal framework, which impacts on policy by generating new debates and creating awareness of new opportunities. Some other notable policy influences are treaties and international agreements, socio-political and economic contexts that define forms of legitimacy of the policy process. Within the Nigerian context, the policy drivers comprise internally induced influences and externally induced influences on Nigeria’s energy policy. The internally induced influences with respect to electricity supply infrastructure in Nigeria are those related to: competencies; expectations; legislation; future visions; and recruiting experts into the energy policy space. The externally induced influences are: the changing nature of international and foreign aid; United Nations Sustainable Development Goals; and international agreements and commitments dynamics

The institutional drivers are characterized by structures or formal organizations which could be government agencies, private sector organizations or political parties. Within the Nigerian context, the institutional drivers of energy systems change are institutional structures and frameworks responsible for three important salient functions, which are: issuance of licenses; permitting; and granting access to historical data

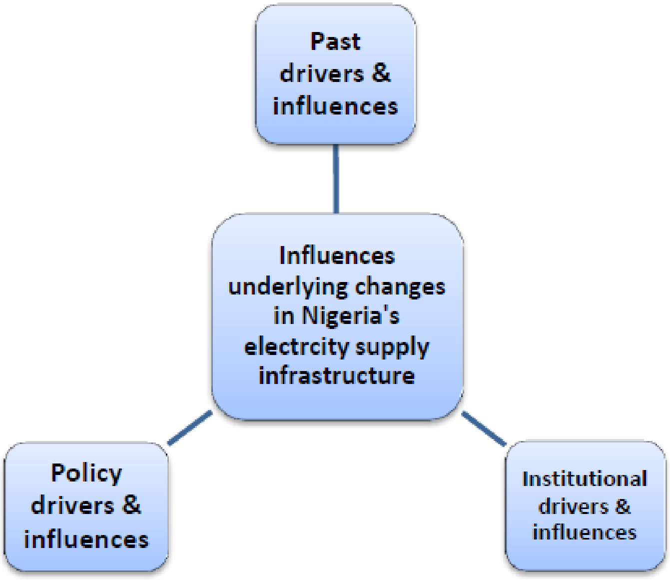

Figure 7.1: Drivers of electricity infrastructure change in Nigeria.

7.2.1. Past drivers of energy infrastructure change

Indeed, this research reveals five important salient aspects that impacted on the historical changes in electricity supply infrastructure. These are:

- Policy and institutional interventions;
- Technological interventions and energy technology pathways;

- Social (societal) practices and public values for energy;
- Available energy resource options; and
- Economic considerations

Some of the historical changes in energy supply infrastructure within the Nigerian context were influenced by the 'elements of practices'. Shove argues that there are three broad categories of the elements of practices which are: *material, meaning*, and *competence* (underpinning the social practice theory perspective) (Shove et al. 2012).

The physical aspects of the performance of a practice (material), the relevant issues considered with respect to the material (meaning) and the skills required to perform the practice (competence) have greatly impacted on energy infrastructure supply in Nigeria through the evolution and progressive energy-intensive nature of various practices that have evolved over time (Shove et al. 2012; Røpke 2009). Commuting and policy making are two important practices that shaped and impacted on electricity infrastructure provision over time in Nigeria as evidenced in chapter 4.

Technological pathways, policy interventions and public values for energy have impacted on the 'material' aspects of the elements of practices within the Nigerian context. The policy intervention of the government in 1946, setting up the then Nigerian Government Electricity Undertaking (NGEU) to develop and implement a 10-year electricity infrastructure provision plan to support industrialization is a concrete example of how policy interventions shaped public values for energy within the Nigerian context. This is evidenced in chapters 4 and 6. Thus, we see policy making practices resulting in new 'meanings' and requiring different sort of 'competencies'. Increased electricity requirement for industry and residential use have also impacted on the need for more electricity infrastructure supply in Nigeria. Indeed, the increased search for cleanliness, comfort and convenience have had great impact on historical changes in electrical energy infrastructure supply based on increased demand for electricity (Shove 2003b; Shove 2003a; Higginson et al. 2015).

Competencies are important in effectively executing a practice. Since policy making is also a practice, it is important that policy makers are equipped with the right competency set that can help them in effectively executing the practice of policy making. Within the Nigerian context, lack of practical knowledge on energy systems and electricity planning (competency) by policy makers involved in energy policy decisions pose a serious challenge on the energy and electricity infrastructure landscape. Indeed, the kind of knowledge the policy makers have are not the type that is required for urgent energy systems change as evidenced in chapters 5 and 6 (Hood et al. 2002; Shove et al. 2012).

7.2.2. Policy drivers of energy infrastructure change

In Nigeria, policy systems, as well as policy actors, play an important role in energy and electricity infrastructure supply. Going into the future, their role will still remain relevant as argued in many literatures (Fischer & Newig 2016; Palm & Fallde 2016). The attitudes, qualities and biases of the political actors within institutional and regulatory frameworks, play a major role in the quality of decision making and governance process in the political sphere within the Nigerian context..

Policy influences arise from the internal dynamics of the decision making structures and institutions which impacts on electricity infrastructure supply. There are two broad (policy) systemic influences in the Nigerian case under study as revealed by this research:

1. The intra-country (internally) induced influences
2. The inter-country (externally) induced influences.

As already addressed in my findings (chapter 5), the intra-country (internally) induced influences are those that arise from within Nigeria. These arise as a result of the internal workings and dynamics of the electricity (and energy) governance structures and institutions. Indeed, these influences which present themselves as challenges are: competency, expectations, legislation, future visions and recruiting experts. These internally induced influences have impacted greatly on Nigeria's electricity infrastructure by creating a supply deficit, incapable of meeting the growing demand.

The inter-country induced influences, which comprises: the changing aid dynamics, United Nations Sustainable Development Goals and the dynamics of international agreements and commitments are greatly impacting on current thinking as to what type of electricity infrastructure should be provided. The externally induced influences are placing demands on Nigeria to ensure that the energy infrastructure mix it choses need have to be one with the least environmental harm and less impact on the climate. As such, most donor agencies, such as the World Bank, European Union, etc., ensure that there is commitment from the Nigerian government on these issues before granting any development aid for electricity infrastructure supply needs.

In highlighting the link between politics, political markets and energy investment decisions (underpinning the techno-economic and institutional perspectives), the question is: why should policy makers be interested in influencing energy infrastructure supply? As argued in literature, there are two main incentives for policy makers and institutional regulatory frameworks to want to influence decisions on energy supply infrastructure (Orlando 2014):

1. The kind of activities engaged in by stakeholders in the energy sector has some systemic implications. These systemic implications are:
    a. *Externalities*: in the forms of public safety, pollution and other interconnected environmental issues.

b. *Network effects*: This results from high interdependencies in energy supply. For example, the electricity sub-sector depends a lot on the downstream oil and gas sector for fuels - such as gas, Low Pour Fuel Oil (LPFO) and High Pour Fuel Oil (HPFO) – used to power most electrical generation plants.

2. The geographically fixed nature of energy resources and the magnitude of investments that get sunk, specific to those geographical locations, constitute an important factor both in energy business and energy infrastructure supply decisions.

Indeed, these aforementioned points are evidenced in my findings as externalities and energy geography forms part of the energy infrastructure debates in the policy making process since the resources needed to power most electrical power plants a concentrated around a particular region of Nigeria.

7.2.3. Institutional drivers of energy infrastructure change

The manner with which institutions rise, and the major pillars that help institutions rise, change and exist (underpinning the institutional perspective) also shape the energy infrastructure governance landscape. These pillars are (Palthe 2014; Henisz & Levitt 2011):

1. *Regulative pillar* – This operates by coercive isomorphism, using force or threats to ensure compliance to rules and sanctions.
2. *Normative pillar* – This operates by normative isomorphism, which ensures compliance to social obligations, accreditations and certifications.
3. *Cognitive pillar* – This operates by mimetic isomorphism, which ensures compliance to things that are generally taken for granted, with prevalence as its major indicator.

Indeed, the Nigerian case, as revealed in this research, evidences that in Nigeria, institutions use of a combination of the three aforementioned pillars by way of threat, norm, and the need for regulatory compliance. Institutional influences on electricity infrastructure supply in Nigeria have been evident, both from a historical perspective, and from recent developments. In pre-colonial times, families and communities took decisions which impacted on energy use and demand. During the colonial era, we saw the rise of institutions specifically set up for planning and provision of electricity infrastructure supply to support economic development and industrial growth. One of such is the Nigerian Government Electricity Undertaking (as detailed in chapters 4 and 6). Post Nigerian independence in 1960, many more institutions were set up to address specific issues in some subset of the electricity sector. An example is the setting up of the Niger Dams Authority to develop Nigeria's hydropower potential (all evidenced in chapter 4).

In recent times, the increasing role of institutions in the electricity sector cannot be over-emphasized. Granting access to historical data/information, formulating regulations and granting permits are three major areas where current electricity institutions exercise authority. Understanding these functions is important within the Nigerian context since the energy and electricity sector have been deregulated, thus, giving room for more private sector participation in the industry. Having a good knowledge of the workings of these institutions, and the pattern they adopt in ensuring regulatory compliance is important for investors in making investment decisions.

Table 7.2 presents a summary of the (policy) influences on electricity supply infrastructure within the Nigerian context as revealed in this research. Indeed, in practical terms, the dynamics of some of these influences led to some unintended consequences of: corruption in overcentralized governance; economic delusion; and increased energy supply fuelled more by external (international) demand as highlighted in chapter 6.

Table 7.2: Summary of influences on electricity supply infrastructure in Nigeria

s/n	Influence types		Influence manifestations	Thesis section
1	Past drivers of electricity infrastructure change		• Policy and institutional interventions on energy • Technological interventions and energy technology pathways • Social (societal) practices and public values for energy • Available energy resource options • Economic considerations	See chapter 4
2	Policy systems drivers of electricity infrastructure change	Intra-country induced influences	• Competencies – lack of practical knowledge of energy policy making among current policy makers • Expectations – changing dynamics of past, present and future expectations from the energy industry • Legislation – the presence of institutionalized (and unwritten) rules/procedures in the energy industry. • Future visions – future visions of the energy industry and the energy market • Recruiting experts – non-systematic way of recruiting new energy and public policy experts into the policy space	See chapter 5
		Inter-country induced influences	• Changing nature of international aid • United Nations Sustainable Development Goals • Dynamics of international agreements and commitments	See chapter 5
3	Institutional drivers of electricity infrastructure change	Historical institutional influences	• *Pre-colonial institutions,* such as; families, kingdoms and communities with energy needs for agro processing, iron smelting, etc. • *Colonial institutions*, such as: Public Works Department (PWD), Nigerian Railway Corporation (NRC), Nigerian Electricity Supply Company (NESCO), etc., with energy needs for infrastructural provisions. • *Post-colonial (post-independence) institutions*, such as: Niger Dams Authority, National Electric Power Authority (NEPA), Electricity Corporation of Nigeria, etc., with responsibilities for energy infrastructure regulation and supply.	See chapter 4
		Recent institutional influence mechanisms	• Dynamics in issuance of licenses/permitting • Regulatory dynamics • Granting access to historical data	See chapter 6

7.3. DRIVERS OF CHANGE IN ENERGY SYSTEMS EVOLUTION

This section presents the key drivers of energy systems change within the Nigerian context based on the findings of this research while contextualizing them within the broader scope of energy systems evolution and existing literature.

At some point in the history of electricity supply systems In Nigeria, there was only one central administrator responsible for long term electricity infrastructure planning and provision, i.e., the National Electric Power Authority (NEPA). Historically, there has been a lot of emphasis on more electricity generation infrastructure to address electricity supply constraints. However, this has left numerous systemic problems on other aspects of the electrical network infrastructure (particularly the transmission and distribution infrastructure) since no corresponding investment was made to improve the transmission and distribution capacity for the additional generation being provided. To address this challenge, the electrical utility company at the time tried to manage electricity demand by adjusting tariff particularly at peak-load times. However, this did not work well as cost benefit analysis did not change an automatic behaviour (European Environment Agency 2013).

In Nigeria, the organization of most electrical power systems today is based on generation capacity and integration of networks, which all started out in the beginning of the twentieth century as local networks. Indeed, this was one of the attributes of Nigeria's electricity system development trajectory. The Nigerian case is a clear evidence that the traditional principles governing the management and organization of energy systems in many OECD countries is being challenged (Crest & Boisseuil 2012).

The traditional notions that have characterized the coordination of traditional energy systems as argued by Crest and Boisseuil (2012) are partly similar to the Nigerian case because for several decades, NEPA was the only central administrator responsible for long term electricity infrastructure planning and provision. However, in recent times, changes in electricity infrastructure systems have been characterized more by political and economic considerations (Crest & Boisseuil 2012). Some examples, which are still at the level of debate within the policy confines of Nigeria include:

- Increasing renewables in the energy mix
- Decentralizing electricity generation
- Role of end-users in energy efficiency, conservation and management
- Flexibility in technical architecture of electricity infrastructure
- The economic architecture and business models in the electricity market

In Nigeria, a very important aspect of the governance of energy and electricity infrastructure provision is the individual interest of policy actors, the individualistic nature of which further emphasizes the need to incorporate economic and social psychological thinking (as I have done here). Some underlying questions they ask themselves before deciding on what type of energy infrastructure to provide include:

- How much does this infrastructure cost? Can our current budget accommodate it?
- How long will it take to deploy this infrastructure? Is it something that I can commission before leaving office?
- What social and political benefits will the provision of this infrastructure confer (on me and the populace)? Will the provision of this infrastructure offer me the possibility of acceptance and possible re-election by the populace?

Indeed, these aforementioned questions are crucial for individual actors within policy frameworks in taking decisions. These also impacts on the governance of energy. This is in contrast with one of the arguments of Kuzemko et al (2016) who asserts that in governing sustainable energy systems change, innovation is important in sustainable energy transitions. In Nigeria, political actor interests are a major driver of energy transitions.

Indeed, one thing that is obvious in the Nigerian case is that the practice of policy making, intertwined with the interests of the political actors, are key drivers of energy transitions. This is supported by the argument (of Kuzemko et al and Mitchell et al) that linking governance with practices and outcomes, and defining energy and climate actor groups are very important in governing changes in energy supply infrastructure in a sustainable way (Kuzemko et al. 2016; Mitchell et al. 2015). These are also relevant in the case of Nigeria as evidenced in chapters 4 and 6 of the research findings.

In Nigeria, institutional (government) interventions, changes in policy direction and new technology pathways constituted major drivers of changes in Nigeria's electricity systems as evidenced in chapters 4 and 6. There are similar trajectories between the energy transitions dynamics of the Nigerian and the Dutch system. In considering the dynamics of the energy transitions in the Dutch electricity systems (1960 – 2004), Verbong argues that: changing perceptions and goals (1960 – 1973); direct government interventions (1973 – 1989); and major changes in rules, network and technology (1989 – 2004) characterized the Dutch electricity sector (Verbong & Geels 2007). The Dutch system compares with that of Nigeria because electricity infrastructure provisions were influenced by: changing perceptions and goals prior to Nigeria's independence in 1960 (1890 – 1960) with evidence in changing technology and fuel sources for electricity generation during that period; direct government interventions (1940 – 1970), an example was the intervention by the then Nigerian Government Electricity Undertaking (NGEU) in 1946; and major changes in rules (2005 - 2015), characterized by the new electrical power sector roadmap. All of these are evidenced in chapter 4 and 6.

7.4. PATH DEPENDENCY, SYSTEMS LOCK-IN AND THE NIGERIAN ENERGY TRANSITIONS.

In this section, I discussed how the dynamics of energy systems change in Nigeria, over time, has led to path dependency and systems lock-in in energy infrastructure technology and institutions. The peculiar features of this path dependency and systems lock-in within the Nigerian context were also discussed.

Path dependency involves doing things the way we know them out of uncertainty about cost of alternatives. It maintains that the starting point (and accidental events) can have significant effects in the course of history. It limits the number of choices we have because the choices we make today depend on choices made in the past, which leads to inertia. Indeed, further developments rely heavily on historical processes, which raise the question if history can teach us lessons that can inform policy today (Stirling 2014; Biermann et al. 2012). Indeed, social practice theory also deals with paths and trajectories as it looks at historical practices. Socio-technical transitions fundamentally involve evaluating paths, trajectories and systems learning.

Within the Nigerian context, the historical decisions on energy and electricity infrastructure provisions have had significant impact on the governance of energy systems and technology in use. The available natural resources also played a vital role in path dependency. In the early 1900s, Nigeria relied on coal-fired electrical power plants due to the availability of coal as a natural resource and the available coal-fired technology at the time. This resulted in the provision of several coal-fired power plants in the country between 1920 and 1950, which led to a technological lock-in supported by the availability of coal as evidenced in chapter 4.

Indeed, infrastructure governance systems can also lead to some form of lock-in. This is manifested through institutional and regulatory frameworks which results in institutional lock-in. In Nigeria, lock-in occurs in one of two ways:

- First is due to a conscious and intentional process whereby decisions are taken based on habitual, attitudinal and behavioural biases by confronting issues and taking decisions without consideration of sufficient alternatives.
- Second is through an unconscious and unintentional motive, whereby lock-in happens as an unintended consequence.

Indeed, these two forms of lock-in that is characteristic of the Nigerian case are evidenced in the findings of chapter 6.

Other issues that possibly contributed to unintentional lock-in in the Nigerian electricity infrastructure landscape were: competencies (lack of practical knowledge) of the individual policy maker with respect to energy policy making; (a lack of understanding of the dynamics of the) energy and electricity legislation process; differing views on future visions of the energy industry (from the policy maker and end-user perspectives); the case of some unwritten rules and procedures in the Nigerian energy industry; and an unsystematic way of recruiting new people into the energy policy space. These issues, as evidenced in chapter 5, led to a case of unintended lock-in in the electricity governance system in Nigeria for decades, until 2005 when a new policy roadmap for the Nigerian electricity sector was prepared to upturn the existing governance regime (Nakhooda 2007).

7.4.1. Technological lock-in

In Nigeria, electricity infrastructure provision is primarily a political choice as evidenced in chapters 4 and 5. Knowledge and understanding of options, as well as the cognitive biases of policy makers shaped the kind of electricity infrastructure we ended up with, thus, leading to technological lock-in. This Nigerian case is deeply supported by existing body of literature.

It has been argued that technological development is influenced by the social, economic, political and economic contexts within which they develop (Rip & Kemp 1998). It can also be argued that the adoption and use of inferior technology are a result of lock-in. However, what is lock-in and how do they come about? Perkins argues that there are two broad overlapping explanations why technologies are subject to lock-in effects (Perkins 2003):

1. *Direction, nature and advances in technology are shaped by the cognitive framework and dynamics of the actors*. This means that advances in technology are shaped by previous experiences, knowledge and ideas, thus, building on past achievements. This has a consequence as it leads to a situation where technological solutions and possibilities outside the current dominant technological regime are excluded or rarely explored as is the case with Nigeria.
2. *Increasing returns of adoption*. This essentially entails the increasing attractiveness that ensues due to the increasing adoption of a particular technology. Thus, technologies that succeeds in winning early adoption success oftentimes ends up in a lock-in situation, and vice versa (leading to a lock-out), following the conditions of increasing returns. This contrast with the Nigerian case because the switch from coal-fired power plants to renewables (hydropower) and later to thermal power plant technology were influenced by the availability of good reserves of energy resources which aided the switch in technology. It was never the case of increasing returns on the use of a particular technology. If that were to be the case, Nigeria should have maintained a lot of coal-fired power plants today.

The principle of increasing returns can be controversial because it can lead society to get locked-in to an inferior design or technology, leading to market failure (Perkins 2003). Indeed, lock-in situations (through increasing returns) occurs as a result of technological choices made at the early stages which are often characterized by ignorance, uncertainty or even non-consideration of the properties and qualities of other options

Redding (2002) argues that there are four essential features of technological change evidenced in empirical literature. These features are:

1. Intentional choices of profit-seeking agents shape innovation
2. The discovery and development of new technologies is an intrinsically uncertain process
3. Technological progress is a result of a combination of ‘fundamental innovation’ and ‘secondary innovation’. Fundamental innovation opens up new frontiers for technological development, while secondary innovation aids the incremental improvements of fundamental innovations, thus, making it realize its potential.
4. Oftentimes, acquired secondary knowledge for one fundamental technology is of little relevance to the next technology.

Redding argues that these four features of technological change provide the basis for path dependence. He argues that depending on the time intervals between fundamental innovations, it could happen that a new fundamental technology may or may not face competition from existing technologies at the profit-maximizing monopoly price (Redding 2002).

Indeed, this is also evidenced in the case of electricity governance in Nigeria. The National Electric Power Authority (NEPA) enjoyed a monopoly of the Nigerian electricity supply market for several decades, until 2005 when the power sector reform act was promulgated which paved the way for private sector involvement. NEPA had responsibility for electrical infrastructure provisions and governance of the various aspects of the electricity value chain comprising generation and supply, transmission and distribution. Between 1972 and 2005, when NEPA was in charge of electricity infrastructure provision and governance, thermal power plant technology for electricity generation dominated new electricity infrastructure landscape. This was partly due to the availability of natural gas reserves in the country which informed government decisions to support such provision. Indeed, post 2005, there has been more gas fired power plants projects. The earlier provision and the presence of available gas reserves has led to a technological lock-in in the use of gas fired power technology. These are evidenced in chapter 4, 5 and 6 as the provision of gas fired power technology has led to increased learnings and knowledge (competency) on the peculiarities of this technology while creating learning deficiency on other technologies.

7.4.2. Institutional lock-in

In Nigeria, institutions played a vital role in electricity infrastructure provisions. Starting with the Public Works Department (PWD) that enabled the establishment and expansion of the first Nigerian electrical power plant, a lot of institutions have either evolved, been dissolved or amalgamated in order to better serve the purpose of electricity infrastructure governance and provision as evidenced in chapter 4. Indeed, within the Nigerian context, the actions of the actors within these institutions are constrained by the rules that govern their existence and functions.

Institutions are organizations established by law or practice. They constitute the 'material' of social life. They are systems of prevalent and established social rules that guide, nurture and structure social interactions. Hodgson (2006) argues that money, laws, systems of measure, language, firms and other organizations can also be referred to as institutions.

Arguably, institutions can either enable or constrain behaviour. Constraints imply the existence of rules, which has the possibility of enabling actions or choices that otherwise would not exist, e.g., electricity interconnection guidelines, which aids the safe connection of generators to the electricity grid. Indeed, regulations are not always the antithesis of freedom, they could also be their ally (Hodgson 2006). However, how do people understand and follow rules?

Social interaction involves a process that inevitably leads to valuation and appreciation of rules. Laws become rules when the laws become customary. However, ignored laws are not rules. New laws become rules only when it is enforced to the point where it becomes customary and acquires a normative status (Schlag 1985; Hodgson 2006). Indeed, social interactions within institutions and the political sphere are governed by formal constraints (such as contracts, legislations and economic rules) and informal constraints (such as code of behaviour and social conventions). Pierson (2000) argues that there are four interconnected and prominent aspects of politics that makes social interaction conducive to increasing returns processes. These are:

1. The central role of collective action (i.e., the collective nature of politics).
2. The high density of institutions (i.e., the institutional density of politics.
3. The possibilities for using political authority to enhance asymmetries of power (i.e., political authority and power asymmetries)
4. Its intrinsic complexity and opacity (i.e., the complexity and opacity of politics).

Building on these, Foxon argues that the aforementioned factors create path dependency and lock-in in particular political institutions and regulatory frameworks (Foxon 2002). Indeed, these aforementioned characteristics of politics have played a major role in the policy process on electricity infrastructure provision in Nigeria. With respect to collective action, political decisions by political actors generally (and energy decisions more specifically) tend towards goals with a ‘winner-take-all’ quality (with politicians seeking re-election, lobbyists seeking political favours, etc.) (Pierson 2000).

In Nigeria, politicians use their authority to impose and generate changes in rules (in both public policies and formal institutions) when they are in position to do that so as to enhance their own power. In the Nigerian case, this has led to choice of electricity infrastructure (thermal power plants) which was based on project execution timeframe more than evaluation of the qualities of other options. Based on execution timeframe, it is possible to complete the engineering, procurement, installation and commissioning of thermal power plants within three years, which falls within single term tenure of a politician, rather than embark on a project that will be commissioned by another administration. Indeed, this has contributed largely to institutional lock-in (with respect to decision practices and rules) and technological lock-in (with respect to the kind of technology we end up with). This process leads to unintended consequences as evidenced in chapters 5 and 6.

7.5. LEARNINGS FROM THIS RESEARCH

This research presents a lot of learnings. These learnings can be classified into four broad areas:

1. Politics plays a major role in effecting energy systems change.
2. Technological changes impact on energy systems change.
3. Energy resources (and the quantity of available reserves) play a major role in the kind of energy infrastructure we end up with.
4. Geographies of energy plays an important role in the type, location, scale and use of energy infrastructure we end up with.

I now discuss this in turn.

7.5.1. Role of politics in energy systems change

Politics play a major role in effecting changes in energy supply infrastructure. For instance, the politics around crude oil and natural gas production and trade is vital for guaranteeing continuity of supply of electrical energy since most electrical power plants depends on the oil and gas sector for fuel to fire the power plants. This means fuel supply (in the forms of liquid fuel and natural gas) for most electrical power plants are highly dependent on the production, market, economics and political dynamics around crude oil and natural gas supply.

Arguably, the gas market is a lot more rigid than the oil market. This is because it requires large and expensive investments to ensure the easy transportation of gas around the world. Investing resources in a lot of long term infrastructure for this sort of business requires that there is a good (long term) political relationship with the trade partners, wherever they may be. Indeed, it is easier to get entangled in the global prospect for natural gas, which can lead to a lot of energy security issues, both domestically and internationally.

Looking into the future, the major factor that could either make or break (clean) energy production is policy. This is the topmost variable because: policy plays a major role with respect to investment direction for most investors; it impacts on changes on the supply side of energy systems and infrastructure through definition of standards; and it imposes considerable changes in energy demand patterns and behaviours.

Within the Nigerian context, a major factor that led to the displacement of coal with liquid fuel and natural gas for electricity generation was simply the economics of natural gas over coal. Coal production and use for electricity generation in Nigeria is more expensive than the use of liquid fuels and natural gas. This transition started happening in the 1950s, but became more entrenched from the 1970s. All the coal fired power plants in Nigeria built from the 1920s to the 1950s have all been retired. Indeed, natural gas will gain a lot more grounds in Nigeria in the coming years due to its availability and the policy direction of the government encouraging the use of natural gas for electricity production.

7.5.2. The role of technologies on energy systems change

In Nigeria, there have been lots of changes in energy technology and use over time. This will continue going into the future. Historically, Nigeria has transited from the use of steam engines, to coal-fired technology, thermal power plants and renewables. Going into the future, there will more changes which will be shaped by the changing nature and politics of electricity infrastructure provision.

Today, there is a rise in the deployment of decentralized off-grid solar solutions in Nigeria. The rapid rise of renewables will continue and solar power will become a regular feature on the energy landscape. New technologies will support global deployment of wind farms and solar solutions (including floating winds for deep sea areas). The rise in renewable solutions needed for a clean energy future will be driven more by the increase in energy demand for electricity. Incorporating these renewable technologies will also have impact on the traditional electricity grid as new hybrid grids (transmitting electricity over long distance) and micro grids (playing strategic role in electricity distribution and providing flexibility) will be the mainstream technologies in the future.

As is now being experienced in major urban centres in Nigeria, buildings are now producing electricity through roof top solar solutions. In the future, more buildings will produce energy rather than consume energy. Buildings will also function as energy hubs in the future, offering the entire energy system more flexibility and also ensuring stability of the electricity grid. The use of smart meters, greater energy storage capacity and low cost solar cells will be important technology catalysts of a cleaner electricity future.

7.5.3. The role of energy resources in energy systems change

Energy sources play a vital role in energy systems change. In Nigeria, it all started with the use of steam engines for electricity generation. The discovery of coal as an energy source (in 1909) changed the energy infrastructure landscape, leading to a switch from the use of steam engines to the adoption of coal-fired power plants. The need to diversify the electricity infrastructure mix led to the development of hydropower plants in Nigeria (with the formation of the Niger Dams Authority). The discovery of crude-oil in commercial quantities (in 1956) had a considerable impact on the electricity infrastructure landscape in Nigeria. The overriding economics of crude oil and natural gas over coal led to a shift to the use of (oil and gas-fired) thermal power plants. Increased demand and consumption of energy in Nigeria have been partly influenced by the availability of energy resources.

Energy flow in society starts with the natural energy sources (such as coal and crude oil) which are then converted into different usable forms that society consumes. These usable forms of energy materializes through the services they render society. This has been evident in this thesis (as presented in chapters 3 and 6) through the greater use of energy resources, driven by the need for comfort and more productivity. In Nigeria, the increased societal use of energy resources is impacted by three main sectors: building; manufacturing; and transportation sectors.

7.5.4. The role of ‘geographies of energy’ in energy systems change

Aside technological interventions, politics and energy resources, a major driver of energy systems change in Nigeria are the ‘geographies of energy’ which encapsulates the social, cultural and political dimensions of energy production and consumption (Frantál et al. 2014). The geographies of energy also considers how territorial, locational and spatial landscape impacts on (and co-constitutes) energy processes (Bridge et al. 2013; Calvert & Simandan 2010).

The geographies of energy played a very important role in Nigeria's energy transitions and infrastructure provision. Prior to Nigeria's independence in 1960, developmental infrastructure projects and provision were centred on regions. Starting with steam powered generation plants in the late 1800s, the discovery of coal in 1909 paved the way for many coal-fired electricity generation plants (mostly around the regions where coal reserves were available). Lagos was the only exception. This was largely because there was already rail infrastructure connecting some parts of eastern Nigeria (Enugu) to Lagos where coal could be easily transported via rail to the power plant in Lagos (as evidenced in chapter 4). Figure 7.2 shows a map of the geopolitical zones in Nigeria.

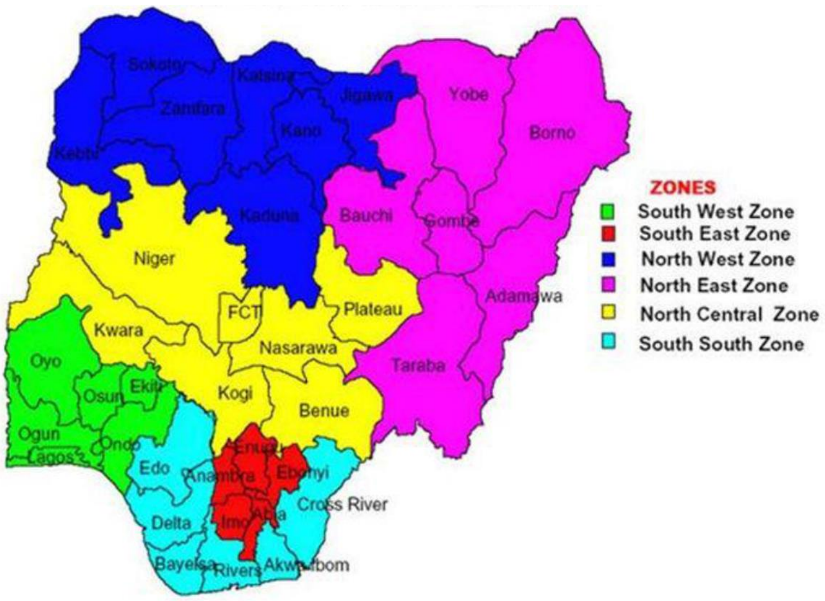

Figure 7.2: Map of the geo-political zones in Nigeria. (Source: http://www.nigerianmuse.com).

Most crude oil and natural gas resources are concentrated around the South-South and South-East zones of Nigeria. These zones also have a higher concentration of: electricity power plants; natural gas refineries and export terminals; and crude oil refineries and export terminals. Indeed, these zones have the highest concentration of energy production and electricity generation infrastructure in Nigeria (Anifowose et al. 2008). However, for political reasons, government infrastructure decisions have also favoured setting up crude oil refineries outside the zones where the resources are. An example is the crude oil refinery located in Kaduna, North-Central Nigeria. The natural crude had to be transported to the refineries via pipelines. Indeed, political decisions of this sort has created historical tensions among socio-political camps in the geographies where the natural resources are domicile (and beyond), leading to cases of pipeline vandalism, political actions and other forms of externalities which impacts on the energy infrastructure landscape and energy security.

7.6. SUMMARY

Summarizing the subject of these discussions and the findings of this research, I hereby present some of the salient issues as suggested by the research findings and evidenced in the results chapters (4 – 6):

1. Energy infrastructure provision is primarily a political choice.
2. Technological changes in electricity supply systems are a major catalyst in shaping the kind of energy infrastructure we end up with.
3. Energy resource availability and reserves plays a major role in the technology choices for electricity infrastructure provision and use.
4. The ‘geographies of energy’ is a major factor that influences energy production and consumption dynamics.

In the conclusions chapter (chapter 8), I will draw on these aforementioned issues and what they mean for the future of electricity infrastructure provisions and governance in Nigeria.

Part V: Conclusions

Chapter 8 CONCLUSIONS

This thesis began by outlining why energy supply infrastructure provision is a priority, covering issues of social cohesion, economic growth, poverty and energy security as key services that energy (infrastructure) provides. However, why should energy supply infrastructure be provided and what are the influences that affect its provision? In chapter 2, I started off the thesis by questioning the assumptions and reasoning behind energy supply infrastructure provision. The underpinning assumptions of five theoretical perspectives were specifically considered: the techno-economic paradigm; social psychology; socio-technical transitions; theories of social practices; and institutional theory were explored. The individualistic approaches of techno-economics and social psychology focus on rational choice and the contextual social norms of the political actors and policy makers, and thereby give little consideration to the role of social structures and contexts. The structural approach of socio-technical transitions focuses on socio-technical rules (and how systems are organized within social contexts) with less consideration on the role of the individual choice and (un)conscious decision-making. The social practices and institutional perspectives focus on practices (doings) and institutional rules respectively. These both operate on the meso level, and hence operate at the middle ground between individuals (micro) and social structures (macro), in terms of units of analysis and foci of investigation. Indeed, as part of the important learnings as evidenced in chapter 4, the individualistic perspectives (techno-economics and social psychology) helped in explaining the findings on the role of the individual as energy users in effecting energy systems change. Socio-technical transitions helped in understanding moments of resource transitions. Institutional theory helped in understanding the key institutional influences on changes in energy infrastructure supply and use, while social practices helped in understanding how the practice of policy making has impacted on the Nigerian energy transitions.

I opted to adopt a pragmatic approach, using a hybrid of theories of the individualistic (techno-economic and social psychology) and structural (socio-technical and social practices) dimensions in investigating Nigeria's energy history and the influences on electricity infrastructure provision. This was a data-led decision, in that when the empirics were pulling me towards considering the role of economics or attitudes of key individuals, then I would draw on some of the individualistic literature when considering how policymakers work within their institutional settings. Likewise, I also sometimes drew on the more systemic level literature when I felt that it could be used in interpreting my data. This theoretical pragmatism served me well and provided a solid foundation for investigating my thesis aims.

It was therefore with primary regard to this theoretical pragmatism that the following central research question was adopted in this thesis:

What are the policy influences on electricity supply infrastructure?

A Nigerian case was used to explore this further. Specifically, Nigeria's past energy history with respect to policy making and energy infrastructure provision was investigated. Nigeria was chosen as the case because no similar studies have been conducted on Nigeria. Moreover, Nigeria has an especially interesting case because of its long energy history, and its increasing role as a major energy and economic player in Africa. Understanding how the policy decision structure has influenced transitions in energy use and energy policy within the Nigerian context, will not only contribute to existing knowledge, but also help in the better future governance of energy industry. Indeed, as Davidsson argues:

> *"…exchange of experiences and the sharing of knowledge gained from solving implementation challenges can make an important contribution towards tackling the challenge of energy transitions worldwide. The countries analysed can learn*

from important parallels and differences in terms of policy making, technology deployment and business model evolution"

(Davidsson 2014b. Pg 2).

The central research question was investigated through three separate thesis sub-questions which formed the basis for chapters 4 – 6.

Sub-aim 1 - How has electricity supply infrastructure evolved over time and what contexts have influenced this evolution?

Addressed in chapter 4

Sub-aim 2 - What exactly constitutes the practice of policy making, and how has this influenced electricity supply infrastructure provision and energy policy?

Addressed in chapter 5

Sub-aim 3 - What are the linkages and consequences of the policy decision processes and institutions in the governance of electricity infrastructure provision?

Addressed in chapter 6

Addressing the first sub-question provides the historical context in understanding the factors that have influenced the trajectory of past and current policy decisions on electricity (infrastructure). The findings of the first sub-question then feeds into better exploring the policy practice influences on energy infrastructure provision and governance (as per the second sub-question). The findings, from both these first and second sub-questions, then feeds into exploring the third sub-question, which looks at the linkages and unintended consequences of the policy practices on electricity infrastructure. Addressing each individual sub-question in turn hence helps to address the central research question of this thesis.

<u>8.1.</u> OVERARCHING CONCLUSIONS: LINKING POLICY DECISION INFLUENCES AND ENERGY INFRASTRUCTURE PROVISIONS

In considering the link between energy supply infrastructure and policy making, this thesis highlights that the choice of ***energy infrastructure provision is primarily a political choice***. However, I am mindful that the term choice implies that there is freedom to act in multiple ways when in actual fact; contexts (e.g., wars, institutional dynamics) were shown to also dictate the direction of the transition in energy infrastructure. It is nevertheless clear that politicians and policy makers have the final say on energy infrastructure provisions, either directly (through direct investment and infrastructure choice) or indirectly (through regulations and regulatory frameworks that guides energy infrastructure choices). It is essentially about the kind of future society that people and government desire to have, and thus the choice is not a solely rational or technical one. Furthermore, these choices are practically influenced by the kind of environmental laws, regulatory standards, and economic incentives that the political class provides through different institutional mechanisms. For example, the banning of inefficient energy products from the market, or political decisions taken by governments to mitigate climate change would certainly affect choices on energy use and energy infrastructure choices. These decisions necessarily influence the energy supply infrastructure we end up with in satisfying our energy demand needs.

Another aspect of the complex link between energy infrastructure provision and policy making is reflected in the ***changing nature, and the politics, of energy infrastructure choices and provision. This has been one of the main drivers (and products) of capitalist society, reflected in the increased demand and consumption of energy***. Different kinds of energy infrastructure shaped the way people lived over time. This has led to energy infrastructure 'lock in" and path dependency with respect to energy supply technology and infrastructure choices. What does this mean for the future of energy in Nigeria? It simply means that Nigeria's future energy infrastructure is already determined (to a certain degree) by the current makeup of the energy system. This clearly demonstrates that in the political sphere it is not just about political choice, because those political institutions are only able to make certain choices based upon the available options.

In the political sphere, ***resource availability is* viewed as *dynamic and 'constructed' by changing economics, technology, and geological knowledge***. This view is seen as a major issue based on data collected. The primary energy resources utilized for energy supply infrastructure, and the energy infrastructure choices, were shaped by geological knowledge of the availability of reserves of energy resources, such as: coal, crude oil, and natural gas. This geological knowledge, which is informed by the economics (costs) and technology involved in energy resource extraction and production, have shaped the dynamics of energy infrastructure choices over time within the fabrics of policy making, as well as energy governance structure. A typical example is the policy direction of the Nigerian government to build more gas fired power plants due to the relative abundance of natural gas reserves and the relatively cheaper cost of natural gas production.

Indeed, following the aforementioned narrative, and linking them back to the learnings from this research (as presented in chapter 7), the overarching conclusions of this research are presented as follows:

1. Energy infrastructure provision is primarily a political choice.
2. Technological changes in electricity supply systems are a major catalyst in shaping the kind of energy infrastructure we end up with.
3. Energy resource availability and reserves plays a major role in the technology choices for electricity infrastructure provision and use.
4. The 'geographies of energy' is a major factor that influences energy production and consumption dynamics.

I hereby present the key contributions of this thesis in the next section, based on the findings and conclusions of this research.

8.2. KEY CONTRIBUTIONS OF THIS THESIS

Sandberg argues that with respect to research,

> "It is important to provide innovative questions which will open up new research problems, might resolve long standing controversies, could provide an integration of different approaches, and might even turn conventional wisdom and assumptions upside down by challenging old beliefs"
>
> (Sandberg & Alvesson 2011. Pg 1-2).

Corley also argues that *originality* and *utility* constitutes two dimensions that currently dominate consideration of theoretical contributions (Corley & Gioia 2011). Corley further argues that originality can be categorized as either (1) advancing understanding incrementally or (2) advancing understanding in a way that provides some form of revelation, whereas the utility dimension parses into (1) practically useful and (2) scientifically useful. In the context of this literature, I now argue that there are three broad areas with which this thesis contributes to existing bodies of knowledge: empirical, methodological and theoretical contributions.

8.2.1. Empirical contributions.

This thesis presents how activities of policy makers and actors, within institutional frameworks, impact on decisions on energy supply infrastructure. The data collected, particularly from the archives of the Nigerian Railway Corporation (NRC), is such that no one has collected and used in the analysis of the Nigerian energy transitions, or even any other associated field. The archival data collected from the NRC, and the subsequent analysis using those data in studying the Nigerian energy transition forms a key part of the empirical contribution of this thesis. This novel manner of connecting historical events and happenings in analysing and producing what could be considered as ‘one of the first set of studies on the Nigerian energy transition’ forms a key part of the empirical contributions of this thesis. It should be additionally noted that no other study has conducted the kind of interviews that I did with Nigerian policy makers, and this thereby represents another empirical contribution.

8.2.2. Methodological contributions

The key methodological contribution of this thesis is to advance the understanding of dealing with high-level institutional players in developing countries. This thesis (in chapter 3) highlights some of the methodological considerations in dealing with high-level policy makers. In particular, specific regard was given to: how to gain access; how to ask and present questions; and how to carry out recordings of conversations with them.

Linked to this, this thesis contributes to a better understanding of how to engage high-level institutional actors and policy makers on cultural and very sensitive issues, such as corruption, in developing countries. Understanding the cultural background and context plays a vital role in the research design in order to choose the best research approach for any study. Going through personal assistants of the target policy maker/institutional actor(s), and the use of a Short Message Service (SMS), are examples of interventions used in this study which were fruits of understanding the cultural context of Nigeria.

Essentially, this thesis would be of real help to anyone researching the activities of policy makers over time in the developing world, especially in the Nigerian context.

8.2.3. Theoretical contributions

This thesis contributes to theoretical knowledge on energy transitions, particularly from a developing country perspective. This thesis is likely to serve as a reference in studying future energy transitions of other developing African countries.

This thesis contributes to knowledge through demonstrating the value of theoretical pragmatism. It contributes to theoretical knowledge by emphasizing the value of interdisciplinarity of theory. This is important as the novel mix of theories enriches the study and provides a platform for understanding the viewpoint and linkages of different theoretical perspectives in relation to the central research question being investigated. Indeed, most energy transitions studies have focussed on the use of the Multi-Level Perspective (MLP) theory with less consideration on other possible approaches. Hence, my adoption of theoretical pragmatism, through combining different theories in addressing the same issue, serves as a major contribution to theory.

The adoption of a pragmatic approach to the use of theory in this thesis has allowed me to better conceptualize the challenges associated with decision making on energy infrastructure within institutional, socio-political and contextual frameworks. Therefore, this thesis, through the use of building blocks for theory development, as argued by Whetten, has contributed to theoretical knowledge through the use of three essential elements of *what*, *how*, and *why* of the Nigerian energy transition, which then leads to investigating the *who* and *when* that constitutes influences on the Nigerian energy transitions (Whetten 2013).

8.3. POLICY RECOMMENDATIONS.

Since this thesis has much to say on the influences underlying changes in Nigeria's energy supply infrastructure, many lessons can also be learnt for current and future policy. This section presents exactly these lessons, with particular reference to what it could mean for a transition to a low carbon economy, both in Nigeria and beyond.

8.3.1. Policy recommendations for Nigeria

The study of the Nigerian energy transitions has some policy implications with respect to institutional roles in energy governance. In order to transition to a future low carbon economy, what has Nigeria got to do? This sub-section presents some important policy focus areas if Nigeria were to transit to a low carbon economy by 2050.

First, there is a need for the Nigerian government to ***define the energy infrastructure and governance nexus*** in order to limit the effects of unintended consequences, as a country's total infrastructure stocks (including energy) also contributes to its GDP. This means setting clear rules and defining (technical and policy) regulations for the effective governance of the (local) energy industry and energy infrastructure provisions. This can be done by understanding the various drivers of energy systems change, and influencing (through regulations) institutional rules that govern the workings of institutional actors in energy supply infrastructure provision within institutional and structural frameworks.

Secondly, considering the linkages between energy infrastructure provision and policy making, ***it is crucial that the governance and provision of energy supply infrastructure be scaled, decentralized and polycentric***, if the challenge of energy access and providing societies with reliable energy services were to be achieved. This means that local authorities (at municipal and state levels) should be able to take decisions on the kind of energy infrastructure they want, and go ahead to provide them, without any regulatory barrier or interference at the federal level, thus, pulling Nigeria to embracing energy supply infrastructure that is suitable for decentralized energy supply systems. This should also apply to private investors as well. This is crucial as the current centralized governance structure of the energy market, and the electricity market in particular, poses a challenge in itself to energy infrastructure supply provision (Goldthau 2014).

In considering energy sources required to power our energy systems, what matters most are: ***the attributes that each energy source presents and the politics around it***. This means that the Nigerian government should *focus on the attributes of each energy source while making energy infrastructure choices*. This includes perceptions of cost, and local environmental harm associated with each type of energy source. Such consideration will help policy makers to formulate their energy (infrastructure) preferences. An example is the current policy of the Nigerian government to massively deploy the use of natural gas for electricity generation, due to resource availability and competitive cost advantage that natural gas presents. The relatively cheap and available natural gas resource has led to more investment in gas-fired thermal power plants. This is an example of energy infrastructure choice informed by the attributes of natural gas as an energy source.

A different way of generating electricity can lead to a shift in preferences. Beyond cost perceptions, a very important factor is the local environmental harm perception. ***Our energy infrastructure choices should be based, where possible, on those with the least environmental harm***. Different energy sources have different degrees of harm associated with them. Fossil fuel based sources, such as coal, is perceived to have a higher environmental harm impact. These factors present themselves as the most important factors in understanding people's attitude towards energy, particularly those used in generating electricity. What does this mean for the future of energy policy, particularly within the context of climate change? The goal will be to *promote cleaner fuels into reduced carbon emissions for our electricity generation*.

Considering some of the salient issues impacting on energy policy making (such as practical knowledge/competencies), it is important for policy makers to ***take more***

advantage of the ever-growing knowledge sharing platforms offered by different organizations at local and international levels to aid capacity building on best practices in the global energy space, while contextualizing them within country level contexts. An example of such an organization is the International Energy Agency (IEA).

<u>8.3.2.</u> Policy recommendations for energy transitions more widely

From the findings of this study, it is highly recommended that *countries formulate a strategy, within institutional frameworks, which underlies their ambition to attain a secure, affordable, sustainable and competitive energy*. This strategy should form part of their transition plan.

This thesis also presents the *need for a greater understanding of the motives and objectives of energy systems supply*. What exactly motivates the changes in the energy sector in a given country as against the background of the overall energy demand and supply situation? (Davidsson 2014b). Possible motives, such as competitiveness, public acceptance, energy security and environmental concerns - within institutional contexts and policy frameworks – needs to be investigated at country levels, for a better understanding of the key drivers of energy transitions within countries.

There is a *need to understand the drivers and governance of changes in the respective energy sectors*. How are changes promoted in the energy sector? Some possible drivers, such as: technological innovation, government policies, etc., needs to be investigated at country level to ascertain their impact on the institutional structures and frameworks of energy policy governance.

<u>8.4.</u> LIMITS OF THIS STUDY

This section highlights some of the limitations – or perhaps more appropriate, limits - of this thesis and the data that it is based upon.

A limit of this study is that it was obviously impossible to interview everyone that had played a significant role in Nigeria's energy transition. Most simply, many had inevitably passed away. Some of the key players 50 years ago have died. As such, it was difficult obtaining data from the interviewees, which dates back to more than 50 years ago. The documentary data gathered from archives was what helped in gaining some insights on the historical policy making practices. But beyond that, some target participants were either out of the country, or had other state assignments that gave them no availability.

In the course of the interviews, I discovered that some of the policy makers were more knowledgeable in policy practices that connect with water and environmental issues rather than energy in itself. However, they were able to provide insights on energy policy practices during the time they served as active policy makers since they had better knowledge of institutional workings and the internal dynamics of decision making within institutions, which is part of the core focus of this thesis.

The political climate in Nigeria at the time of the interviews also impacted on the research. The interviews were conducted during the electioneering period in Nigeria in 2015. Election periods were characterized by uncertainties. Sensitive matters, such as corruption, can be quite difficult to address during an interview session (considering the political climate at the time). Some interviewees (who did not partake in the research) perceived the research interview as a tool planted by their political opponents to obtain their views on certain sensitive issues. Indeed, this resulted to only twelve people agreeing to partake in the research. However, those interviewed were truly representative of the target institutions for the study.

Another limitation was the possibility of personal bias by the researcher during data collection and analysis which could affect the reliability and validity of the study. In order to avert this, I ensured all the finding chapters went through a thorough external peer review process by other experts in the field so as to be able to address issues of possible bias should in case they arise. Indeed, all of the results chapters have gone through peer review process and have all been published in refereed academic journals.

In consideration of the limits of this study, the next section presents some areas of possible future research based on the learnings gained in this thesis.

8.5. AVENUES FOR FURTHER RESEARCH

This section presents some areas for possible future research. It starts by presenting some avenues for further research with respect to the individual results chapters, and then goes on to highlight some important areas for further research in line with the central research theme.

8.5.1 Nigeria's energy transition

The analysis in chapter 4 presented Nigeria's energy transition with respect to the evolution of energy infrastructure provision. The study focussed on the interaction between energy demand, technologies used in satisfying the demand and the primary energy resources used in satisfying the demand. Another possible way of carrying out this study could be to focus on energy infrastructure itself and to highlight the key factors that led to the technology shift from one energy system to another (Chappin 2011). This can be explored by further research.

8.5.2. Energy policy transition

The analysis in chapter 5 presented the factors affecting the performance of the Nigerian energy industry. The study revealed that these factors are consequences of the policy decision governance structure on energy infrastructure. A possible area that can be filled by further research is to study the historical evolution of energy policies in

Nigeria (Florini & Sovacool 2009). These sorts of study have not been done for Nigeria and many developing countries.

8.5.3. Policy models for energy governance in developing countries

The analysis in chapter 6 presented the linkages and unintended consequences of the policy decision governance structures and institutions. It also stressed that the policy cycle models never really worked in reality in the Nigerian case. Some questions which can be covered by future research include: what policy decision models can be adopted in the governance of energy infrastructure provision that produces the least unintended consequences? How can energy policy decisions in developing countries be improved within the context of their geography? (Goldthau 2013). This sort of studies has not been done for Nigeria and many developing countries.

8.5.4. Water infrastructure

The methods adopted in the study of Nigeria's energy infrastructure, as presented in this thesis, can be used in carrying out a similar study for understanding water infrastructure transitions over time. How has water infrastructure evolved? Within what policy contexts have water infrastructure been provided? What infrastructure provision and/or policy contexts have influenced increased demand for water? (Nastar 2014). These studies have not been done for Nigeria, and indeed, many developing countries.

8.5.5. Water-energy nexus

More generally, an important area for further research is a study of the Nigerian water-energy nexus with respect to resources, environmental and climate impact. How much water is required for energy, particularly water required for coal mining, oil production, hydropower generation, etc.? How much energy is required for water production, particularly water extraction, treatment, distribution, waste water collection, waste water treatment, etc.? How has the Nigerian water-energy nexus impacted on energy and water policies? What impact has the Nigerian water-energy nexus had on energy governance and water governance? What are the climate implications of the Nigerian water-energy nexus? (Workman et al. 2014). These are important questions that can be filled by further research as this study have not been done on Nigeria and, indeed, many developing countries.

8.5.6. Transportation infrastructure

The methods adopted in this thesis can be used to conduct a similar study on the evolution of transportation infrastructure. There are not many studies that have focussed on the historical transitions in transportation infrastructure in Nigeria, and indeed in many developing countries. What contexts have influenced the provision of transportation infrastructure over time? Studies that have been done only captures snapshots of different transport infrastructure, such as railway, road, air and water transportation infrastructure (Verron 2015). However, there is a need to conduct a holistic study in understanding what led to the transition from one transport mode to another, over time. This gap can be filled by further research.

8.5.7. Food systems infrastructure

Another important area where the methods adopted in this thesis can be used is in the study of food systems infrastructure. How have food systems infrastructure evolved? What policies have aided increased provision of food systems infrastructure? (Jurgilevich et al. 2016). Again, these sorts of studies have not been conducted for many developing countries.

8.5.8. Cross-cultural longitudinal studies

The methods used in this thesis can be adopted in carrying out cross-cultural comparisons of different longitudinal datasets for studying energy transitions in different countries (Wilhite et al. 1996). This can be done by correlational studies that involve observing the same set, or similar set, of variables over a long period of time.

8.5.9. Energy futures

Some of the methods used in this thesis can be adopted in carrying out a study on how policy makers envisage the future of society, with respect to the desired 'essential services', and what that then means for the emergence of (energy) infrastructure. This can be explored by further research.

8.6. FINAL THOUGHTS

The study of Nigeria's energy transitions presents some policy implications. Since energy infrastructure choices contribute to environmental problems, and changing these energy infrastructure choices requires adequate knowledge of their effects and consequences, there is need for a wide range of changes in energy policies and energy systems to help address these problems.

Energy users, including policy makers, generally prefer energy policies that is perceived to have more benefits and less cost. However, since energy infrastructure provision is primarily a political choice, the acceptance of different energy policies (and changes in energy supply systems) is influenced by institutional actors within institutions through institutional values, workings and frameworks responsible for energy infrastructure decisions and choices. .

Energy production, distribution and supply are very complex matters. This complexity is evident when viewed with respect to the role of technology, energy resources and geographies of energy in effecting changes in energy supply systems. This implies reliance on parties, such as: energy companies, scientists, non-governmental organizations and policy makers. How much people trust these parties will influence the acceptability of energy policies.

To summarize, in this thesis, I have presented the influences and unintended consequences of the policy decision processes and structures, and their role in Nigeria's energy transitions. Knowledge and understanding of Nigeria's energy past can surely shape current and future decisions. Short term energy decisions have to be put in perspective with the longer term visions in order to limit the effects of unintended consequences.

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Appendix 1 - PARTICIPANT INFORMATION SHEET

Anglia Ruskin University

Cambridge Chelmsford Peterborough

1.1

This sheet gives you more information about the study and what it involves. Please read this carefully before you decide whether or not to take part. If you have any questions, please ask me.

1.1.1 Section A: The Research Project

1. Title of project

   Investigating the influences underlying past changes in energy supply infrastructures

2. Purpose and value of study

   The purpose of this study is to gather historical data – based on the lived experiences of the participants – in order to ascertain how policy making, as a practice, have impacted and influenced decisions on new energy supply infrastructure provision.

3. Invitation to participate

   I would like to invite you to take part in this research and share your views, experiences, and knowledge for the study. Before you decide you need to understand why the research is being undertaken and what it would involve for you. Please take time to read the following information. Ask questions if anything you read is not clear or would like more information.

4. Who is organising the research

   The study is being undertaken by Norbert Edomah for his PhD research. The study is under the supervision of Dr Aled Jones, Director, Global Sustainability Institute, Anglia Ruskin University, United Kingdom.

5. What will happen to the results of the study

   Interviews will be analysed and results written up. The interview results will be analysed in a manner that the names and identity of the persons involved in the interview will remain anonymous. Results will be published in academic papers and the PhD thesis.

6. Source of funding for the research

   Private funding from the research student.

7. Contact for further information

Norbert Edomah

PhD Researcher

Global Sustainability Institute, Anglia Ruskin University.

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Dr. Chris Foulds

Second Supervisor

Global Sustainability Institute, Anglia Ruskin University.

Cambridge, CB1 1PT, England

E-mail: Chris.Foulds@anglia.ac.uk.

1.1.2 Section B: Your Participation in the Research Project

1. Why you have been invited to take part

   You are invited to take part in this research as an experienced official whose views could contribute to increase knowledge on the research subject.

2. Whether you can refuse to take part

   You are under no obligation to take part in this research. You can also withdraw at any time without giving a reason.

3. Whether you can withdraw at any time, and how

   You have the right to withdraw from the interview at any time (during and after the interview) without giving any reasons. Please inform the researchers through the contact details provided (in section A, number 7) if you want to withdraw and all the information collected from you will be destroyed.

4. What will happen if you agree to take part (brief description of procedures/tests)

   The researcher will arrange a face-to-face interview with you. Location and time for interview will be agreed with you well in advance. You will be requested to sign a consent form, a copy of which will be given to you to keep along with this information sheet. Interview will last about 60 minutes. To make sure that your views are represented correctly in the study, preferred method of taking interview notes would be digital recorder. As soon as the interview recording is converted to text data, it will be erased. However, if you do not wish a digital recording, the researcher will take interview notes on paper. Participants will NOT be identified by name in the thesis unless they indicate otherwise.

5. Whether there are any risks involved (e.g. side effects from taking part) and if so what will be done to ensure your wellbeing/safety

   Interview will collect your views from your experiences and do not involve any risks of wellbeing. You can withdraw from study at any time without giving any reasons.

6. Agreement to participate in this research should not compromise your legal rights should something go wrong

   All of the information you give will be anonymous so that those reading reports from the research will not know who has contributed to it, unless you explicitly agree that your name may be made public. Nobody other than the researchers will have access to the data. If you have a concern about any aspect of this study, you should ask to speak to the researchers who will do their best to answer your questions.

7. Whether there are any special precautions you must take before, during or after taking part in the study

   No special exceptional precaution is required at this stage of the research.

8. What will happen to any information/data/samples that are collected from you

   The information you give will be used along with the information from other participants to write PhD thesis on the research subject.

9. Whether there are any benefits from taking part

   You have been chosen for interview because of your knowledge/experience and your participation will help to increase the knowledge on various elements involved in the practice of policy making on new energy supply infrastructure provisions. In addition to my academic achievement, results from study when published, would be beneficial for various stakeholders, research institutions, consumers, regulators, SMEs and natural environment. If you wish to receive copies of these outputs please let the researcher know and these will be sent to you.

10. How your participation in the project will be kept confidential

All information which is collected from you for the research will be kept strictly confidential, and any information about you will be removed so that you cannot be recognised.

YOU WILL BE GIVEN A COPY OF THIS TO KEEP,

TOGETHER WITH A COPY OF YOUR CONSENT FORM

Appendix 2 - PARTICIPANT CONSENT FORM

NAME OF PARTICIPANT:

Title of the project: **Investigating the influences underlying past changes in energy supply infrastructures in Nigeria**

Main investigator and contact details: ***NORBERT EDOMAH.***

PhD Researcher, Global Sustainability Institute, Anglia Ruskin University, Cambridge, CB1 1PT, United Kingdom. Mobile: +2347038264790.

E-mail: Norbert.Edomah@student.anglia.ac.uk.

Members of the research team***:***

Dr Chris Foulds (main supervisor), Dr Aled Jones (2nd supervisor).

1. I agree to take part in the above research. I have read the Participant Information Sheet for the study. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University[1] processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me*

Name of participant (print)………………………….Signed………………..….Date………………

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: ***Investigating the influences underlying past changes in energy supply infrastructures.***

2 I WISH TO WITHDRAW FROM THIS STUDY

Signed: ___________________________________ Date: _____________________

[1] "The University" includes Anglia Ruskin University and its partner colleges

Guidance on Effective Risk Assessment

Step 1 Identification of hazards

Carry out a hazard identification exercise to ensure that all potential loss or injury/illness making situations has been identified. This will be based on the activities carried out within the University and consist of:

- A review of all tasks covering: operational, maintenance and emergency procedures
- The responsible Dean/Head will draw up an assessment schedule. In determining this schedule they will take into account perceived risk levels, and frequency of use.

Step 2 Identify who is at risk and how

Examine tasks with perceived high or medium level risks to identify:

- Who could be exposed to the hazard and be at risk.
- How equipment and substances are used (and how the exposed persons are put at risk) by direct observation taking into account the following factors:
  - Premises.
  - Work station factors.
  - Substances.
  - Machinery and equipment.
  - Environmental emissions and waste disposal.
  - Legislative requirements. and
  - The presence and activity of other persons who could be in the vicinity.
  - Comments form employee representatives
- This information will be recorded, were appropriate on a flow chart, and hazardous activities/situations noted.

When undertaking hazard identification, assessors will consult relevant sources of information, e.g.:

- Legislation.
- Health and Safety Commission Approved Codes of Practice.
- Health and Safety Executive Guidance
- Manufacture/supplier product information.
- Relevant British and International standards.
- Industry or trade association guidance.
- Accident, ill health and incident data. and
- Personal knowledge and experience of managers and employees.

- Expert advice and opinion.

Step 3 Identify the current risk control measures

On identification of a hazard the assessors must identify the maximum likely injuries or damage that could result if an accident occurred while the task was being carried out. In doing so they will take into account:

- The location, e.g. indoors in an office, in a plant room or print room, on the roof, etc.
- Local environmental factors, e.g. lighting levels, underfoot conditions, weather, etc.
- The persons exposed, new starters, training and experience, sex, fitness, etc.

The likely injuries or damage that could result from the accident will be categorised as:

Fatal	Probability of deaths, or catastrophic damage or process interruption.
Major	Probability of major injury or major damage or process interruption.
Significant	Probability of injury resulting in loss of three or more working days or serious damage or process interruption.
Minor	Probability of minor injury that would cause no lost time, minor damage or process interruption.

The likelihood of an accident occurring will be estimated taking into account the:

- Numbers of people exposed to the risk.
- Frequency at which the task is performed.
- Effectiveness of any current control measures.

Note, any current control measures currently in place must be recorded against each hazard that could result in significant, major or fatal injuries.

The risk associated with the task will be prioritised using the matrix shown below.

Likelihood ↓	Severity of outcome *Minor Injury **or** little or no damage/ process interruption*	Severity of outcome *Significant injury **or** serious damage/ process interruption*	Severity of outcome *Major injury **or** major damage/ process interruption*	Severity of outcome *Death **or** catastrophic damage/ process interruption*
Improbable	LOW	LOW	LOW	LOW
Remote	LOW	LOW	MEDIUM	MEDIUM
Possible	LOW	MEDIUM	MEDIUM	***HIGH***
Probable	LOW	MEDIUM	***HIGH***	***HIGH***
Likely	LOW	MEDIUM	***HIGH***	***HIGH***

HIGH PRIORITY	**ACTION IMMEDIATELY.**
MEDIUM priority	Risk important-action within 1 month.
LOW priority	Risk insignificant action only if cost is low and change is easy to implement.

For HIGH and MEDIUM rated risks the assessors must describe against each risk the control measures that they recommend should be introduced to reduce the risk to tolerable levels.

NOTE: WHERE FULL IMPLEMENTATION OF CONTROL MEASURES CANNOT BE ACHIEVED AT THE TIME OF ASSESSMENT, ADEQUATE TEMPORARY STEPS MUST BE TAKEN, TO MINIMISE THE RISKS.

When allocating control measures the general preferred hierarchy of risk control principles must be followed:

- **Eliminating** risks, e.g. by avoiding the use of high-risk processes or materials.
- **Substituting** a less hazardous material or process
- **Combating** risks at source by engineering controls, positively isolating or separating individuals from the hazardous part or substance
- **Minimising** the risk by the design of suitable systems of work, or by the use of personal protective equipment which should only be used as a last resort

In determining additional or alternative control measures required the sources of information identified above should be consulted. In addition the need for support measures, such as, authorised users, training, supervision, inspections and scheduled maintenance should be determined.

These new risk control measures must be recorded.

After the application of each control measure, the risk level must be re-assessed and if still medium or above additional controls applied until the residual risk is reduced to low.

Note, some of the duties imposed by relevant statutory provisions are absolute and must be complied with, e.g. the requirements of the Provision and Use of Work Equipment Regulations.

When the risk control procedure is applied to meet practicable, or so far as reasonably practicable, or similar legal requirements the assessors must consider the following factors:

- The application of up to date technology.
- An assessment of the options available.
- The relative costs and efficiencies of the options.

Justification of the costs of the proposed control measures.

Step 4 Record Findings

Ensure that a comprehensive record of the significant assessment findings has been prepared. This must be in sufficient detail to permit reviewers to follow the assessment process and verify the adequacy of the exercise. Note the assessment record may be needed to help develop training plans and on occasion assist in the investigation of accidents.

The record should clearly identify:

- What was assessed and the associated hazards.
- Who was at risk and how the exposure occurs.
- The risk level and the adequacy of the existing controls to meet legal and good practice requirements. If risks are not adequately controlled suitable alternative and or additional controls must be identified. In addition the record must identify that any required additional or alternative control measures have been implemented.
- Who carried out the assessment, when it was done and a date by which it must be reviewed.

Step 5 Review and revise

All assessments must be reviewed and as necessary revised by the date established by the previous assessment. In addition the assessment will be reviewed whenever there is reason to believe that it is no longer valid. This may be due to an accident, inspection findings, or changes in operational or good practice or legal requirements, etc.

Subject of assessment (May be an activity, hazard or relate to an individual)	RA conducted by.	Date.	RA ref. no.
A research study to investigate the influences underlying past changes in energy supply infrastructures in Nigeria. Dates: May 2015 Location of research: Nigeria	**Norbert Edomah**	**15/04/2015**	**ARU/SEPT/2014**

List the risk/s involved or describe the hazard

A list of potential risks involved in the field work are as below

- Risk of participant (interviewer) feeling unwell
- Duration and type of questions during interviews
- Lone Working of Researcher in field
- Storage of confidential information from the research
- Welfare of the participants during the interviews
- Welfare of the researcher during the interviews and information gathering
- Method of transport – (car, bus, air)
- Road Traffic Incidents
- Distance of travel for interviews

List the current control measures in place. Please check the RM website for help and advice available at; http://my.anglia.ac.uk/sites/risk/default.aspx

Above risks can be eliminate/minimise/control as below:

- ARU Risk assessment Policy
- Supervision of research by ARU Supervisor (Dr Aled Jones)
- Participant Information Sheet provided for each participant & a Consent form to be completed by participants
- Carry a mobile phone at all times and ensure supervisor knows of location and times
- ARU Public Liability Insurance in place
- Breaks during periods of long car journeys for interviews

- Pilot study of potential questions for participants

Current risk level. **Medium**
(See risk matrix)

List the actions required to reduce the risk, include reference to any written safety procedures. Please check the RM website for help and advice available at; http://my.anglia.ac.uk/sites/risk/default.aspx	Date actioned	Actioned by
Following actions will be undertaken to eliminate/reduce/manage risks • Regular supervision meetings with Dr Aled Jones • Confidential information to be stored securely and to be deleted after assessment • Welfare of participants to be considered during interview • Researcher to take regular breaks during interviews • Itinerary of interview dates, times, locations, and participants names to be provided to Supervisor • Consent form to be obtained from participants	**May 2015 to November 2015**	**SKC**

Revised risk level. **Low**
(See risk matrix)

RA verified by (Usually Dean/Head of support unit/Line manager)	Date.
Dr Aled Jones **(Supervisor must sign here to agree/verify the risk assessment)**	
Risk assessment issued to the following; **Dr Aled Jones (main supervisor), Dr Chris Foulds (2nd supervisor).** **(List anyone that needs to see a copy – FREP Panel, Supervisor, Risk Management, etc)**	Date.

Risk assessment review date. (Usually annually)						
Risk assessment reviewed by.						

Appendix 4 – RESEARCH INTERVIEW PROTOCOL/DISCUSSION GUIDE

Investigating the influences underlying past changes in energy supply infrastructure

Introduction -

- Thanks for accepting invitation to participate in the research.
- Self-introduction. – Norbert EDOMAH. A PhD researcher, and a member of the Consumption and Change Research Group at the Global sustainability Institute, Anglia Ruskin University. United Kingdom.
- Purpose: - I am currently investigating the influences underlying past changes in Nigeria's energy supply infrastructure through studying the relationship between energy infrastructure provision and policy making. I am focusing on the Nigerian case. I am having this discussion with you because you have been identified as someone whose knowledge and views on the subject could contribute in advancing knowledge on this subject.
- Our discussion will be confidential and anonymous. Audio-recording will NOT be used owing to the Nigerian cultural context and the current political climate (election period). This is to help you be free in our discussion. I will take note of some vital points using pen and paper. Data will be analyzed in a manner that your name and identity will not be revealed.
- The interview will last approximately 50 minutes. There are no right or wrong answers. What matters most are your personal views on the subject

Some sample questions.

- Could you kindly tell about your (family, educational, and professional) background?
- Could you share your experience in the energy industry.
- What are the key issues you have observed with respect to electricity supply infrastructure provision over the past decades? Can you share your thoughts o these issues?
- Can you describe how you eventually found yourself in the policy space?
- Can you tell me about a typical day in the parliamentary office?
- From your experience, how has energy policy legislation been done?
- Can you shed light on the process of *white-washing a bill* as seems to be the case of the Petroleum Industry Bill (PIB)?
- Can you describe your role as a special adviser/assistant to the President on policy implementation?
- Can you describe a current issue you are taking care of and what concrete actions you are taking in tackling the issue?

Appendix 5 – EXTRACTS FROM DOCUMENT SEARCH

"Document extract from archives of the Nigerian Railway Corporation as compiled by Francis Jackel '*History of the Nigerian Railway*' (volumes 1-3) have been removed to protect copyright".

Appendix 6 - ETHICS APPROVAL LETTER

Dear Norbert

Re: Project Ethics Proposal

Project Title:	Investigating the influences underlying past changes in energy supply infrastructure.
Principal Investigator:	Norbert Edomah
DREP Number:	EHGSI-14-007

I am pleased to inform you that your research proposal has been approved by the Chair of the Departmental Research Ethics Panel (DREP) and ratified by the Faculty Research Ethics Panel under the terms of Anglia Ruskin University's Policy and Code of Practice for the Conduct of Research with Human Participants. Approval is valid until the submission date. If you require additional time please contact me for an extension.

It is your responsibility to ensure that you comply with Anglia Ruskin University's Policy and Code of Practice for Research with Human Participants and specifically:

- The procedure for reporting adverse events and incidents.
- The Data Protection Act (1998) and any other legislation relevant to your research. You must also ensure that you are aware of any emerging legislation relating to your research and make any changes to your study (which you will need to obtain ethical approval for) to comply with this.
- Obtaining any further ethical approval required from the organisation or country (if not carrying out research in the UK) where you will be carrying the research out. Please ensure that you send the DREP Secretary copies of this documentation.
- Any laws of the country where you are carrying the research out (if these conflict with any aspects of the ethical approval given, please notify DREP prior to starting the research).
- The British Psychological Society Code of Human Research Ethics and other relevant guidelines.

Due to health and safety regulations students may only work in the departmental laboratories between **9-5pm Monday- Friday**. Work can only take place when a psychology technician or your supervisor is present in the department to provide support. Please also note that your research may be subject to random monitoring by the committee.

If you make changes to any aspect of your approved research, it is important that you discuss this with your supervisor as they can advise you on whether you need any additional ethical approval.

Yours sincerely

Dr Flavia Cardini

Chair of the Departmental Research Ethics Panel

APPENDIX 7 – EXTRACT FROM INTERVIEW NOTES

This appendix presents some extracts from the interview notes developed after the interviews for some of the interviewees**.**

Interviewee Z

Growing up, I had planned to be a medical doctor. I still wander how I managed to be an engineer and now one of those responsible for maintaining the electrical transmission infrastructures for one off the busiest and sophisticated regions in Nigeria.

During the times of the Electricity Commission of Nigeria (ECN) and the Niger Dams Authority (NDA), electrical network infrastructure provisions were in line with the demand. There was clear planning, and the projections and plans were followed. As such, demand and supply of electrical energy were commensurate. As population grew, improperly formed policies ended up as the real bottle neck to the advancement and provision of new energy infrastructures to meet the rising level of demand.

It should be noted that demand for energy (particularly electricity) was quite low at some point in the history of Nigeria. The focus was more on electrical energy requirements for lighting in residential areas, and for a few workshops and industries.

While all the growth in demand was being experienced, the installed capacity of the electrical network infrastructures remained static and stagnant. There were no new investments for some decades. Today, the electrical supply network is overstretched as the capacity is limited. Throughout the no-show decades, the only project that was done was the Egbin gas turbine project which started in 1986 and was completed in 1996, making it the biggest thermal power station in Nigeria. The Egbin power plant was built after almost 30 years of the provision of the major hydro power plants (Shiroro and Kainji). Even with the provision of the Egbin power plant, demand was still far greater than supply.

During these decades of non-provision of new energy supply infrastructures, there was also the challenge of non-investment in the periodic turn-around maintenance of the power plants. This led to a further drop in the overall efficiency of most of the existing power plants to about 50%. Due to the increased demand, and the inability to cope in terms of supply, backup power plants were brought to the mainstream. Even at that, the demand for electrical energy still by far outweighed the supply.

Policy makers did nothing about the situation. On many occasions, successive governments thought they can perform the magic of constant electricity supply by appointing new ministers and directors at the helm of affairs of major agencies. This only worsened the situation. Policy makers only adopted the blame culture rather than focusing on addressing the core issues in the electricity sector, as such, they only aggravated the problems. No serious attempt was done to correct the anomalies, neither were new power plants built to accommodate the increased demand.

After a long period, there were some serious attempts made in 2005, with a clear roadmap on correcting the anomalies. This led to the new electrical power sector reforms. However, the reforms were placed on hold as the next President that came into power in 2007 is from a region of the country were they feel that electricity provision is the sole responsibility of the government and the populace are not meant to pay for that. This led to a halt in the process of implementation of the roadmap for some years until the Goodluck Jonathan administration managed to complete the first phase of the privatization of the electrical power utilities and network. The fundamental error with the reforms is as follows:

Some interesting things (which forms part of the effects of ineffective planning) was the building of power plant (Omotosho) without consideration for gas infrastructure to power the electrical power plant. One of the major policy deficiency of the privatization process was that there were no deadline given for new power plants owners to invest in new energy infrastructures or to improve existing ones.

It was argued that the current Transmission Company of Nigeria (TCN) transmission network infrastructures cannot transmit electrical power more than 4000MW consistently. However, the TCN just recently concluded Mechanized Line Tracing for the transmission network around the country and is currently transmitting 4500MW consistent power.

Interviewee Y

Policy making at state level actually has some very different dynamics as compared to what happens at the federal level. At federal level, members of the legislature can propose, and sponsor bills. They explore all sorts of mechanisms and lobbying processes to ensure the bill they sponsor is passed to law. At state level, most bills originate from the executive arm of the state. The bills are then passed to the state legislature for the legislative process that gets the bills become laws. The state legislature have very limited powers to recommend possible projects and ideas through bills. When they try to do that, the state executive tends to see it as an infringement to what is supposed to be their responsibility as the executive arm. They interpret such actions as trying to tell those in the executive arm that they are incompetent. This is one of the causes of friction between most state legislative assemblies and the state executive.

Powers lie more in the state executive for policy formulation and implementation. Many Nigerians do not understand this dynamic yet. Most people expect so much from the state legislators not realizing that they (the people) stripped them (the state legislators) of everything that can make them influence the decisions and happenings as regards the governing of the state. The only way they can influence decisions is by frustrating the passage of a bill.

Lagos is the only state where the budget and spending of the legislature is autonomous and independent of the state executive (the executive governor) for approval. In all the other states of the federation, the governor has to approve the spending and budget of the state legislature. There are usually frictions between the two arms of government at the state level that are caused by the lobbying process employed by either party to satisfy their interests. When the executive governor needs a bill to be passed to law that is being frustrated by the state legislator, he can decide not to approve their budget or spending, thus, using that as a tool for lobbying and vice versa.

With regard to policy, there is a huge policy gap. This is primarily caused by the lazy will of those in political power. With regard to energy and policy interplay, quite a lot happened in Lagos

Interviewee X

Your research question looks very interesting and I am sure many people will be interested in the outcomes of such research.

With regards to energy demand evolution, the energy and electricity sector has failed, just like any other sector of the economy, primarily as a result of failure of national planning process. Nigeria, as a nation, have lost the planning culture as no serious national planning was done for a long time. The last national planning was done by the Yakubu Gowon administration (1966 – 1975). The successive national planning that was done prior to the last one done by the Yakubu Gowon led administration focused on different aspects of national life and planning for current and future provisions of various infrastructures such as electricity, water, transportation, industrialization, among others in order to cater for the current needs at that point, and also for the future needs which were influenced by increased demand caused by industrialization, urbanization, and growing population.

Electricity and railway transport provision were great contributors to industrialization which also influenced the rise in energy demand and consumption. Electricity generation in Nigeria started in the early 1900's. This provision led to the rise in the industrial and commercial activities which further influenced demand. Industrialization and energy demand continued to grow as the more businesses sprang up. Massive industrialization continued until the 1970s.

The Niger Dams Authority was set up to manage and develop the hydro-power potential for the country. It was through that that the Kanji and Shiroro dams were constructed (among other dams). The Electricity Commission of Nigeria (ECN) was also formed to manage all the diesel and coal fired power plants in the country. The National Electric Power Authority (NEPA) was a result of a merger of both the ECN and the Niger Dams Authority so as to have a single umbrella body responsible for the generation, management and planning of electrical power infrastructures in Nigeria. The period of the merger and the formation of NEPA coincided with the period when Nigeria saw the last serious national planning.

At this time, in the 1970's, there were many industries. Industrialization was at its peak in Nigeria. Electricity demand was growing geometrically, and there was need for fidelity to the implementation of the national planning agenda on electrical power in order to ensure that industries and the industrialization process is supported. Planning was done since the 1920's that foresaw the future growth of energy demand and consumption. Most of the national planning that was done in Nigeria was done during the colonial times. After the 1970's, Nigeria experienced a massive de-industrialization. The de-industrialization was caused not only by the impact of some decisions under the military rule, but also by insufficient supply of electricity to meet the industrial demand. As such, energy consumption declined more due to de-industrialization. Lack of electricity led to de-industrialization. What is currently projected as the estimated electricity demand is something very fictitious and does not reflect reality. The provision of more energy infrastructures will awake a new phase of demand. More people who were not able to use certain kinds of equipment due to non-provision of electrical power will start to use them, those who have relied on local generating sets for electricity generation for their businesses will start to weigh the options of connecting to the public utility, among others which will really impact on a new phase of increased demand.

What we need is a diversified energy mix. We have ample primary energy resources that can be used for electricity generation which we are not currently exploring (some of them we have explored in the past and later abandoned). We can build power plants using different energy resources with focus on siting the plant close to where the resources are (coal fired plants in Enugu and environs, hydro power around the Mambila plateau, gas fired power plants around the Niger Delta region, among others).

One can imagine that as far back as the 1980s, we have had a lot of the situation that plays out in our political system today. I had a permanent secretary whose task it, is as it seemed, to remind me of the various "heads, and feet and toes" one would step on if we were to proceed to implement some policies as formulated. At some point I had to ask if there was anything at all that can ever be done without "stepping on someone".

There are several policy issues in Nigeria. However, the major issue that affects policy is the **"**centralized system of decision and policy making". It all started with the marriage between the military and oil. Nigeria was created as a federation where the various states/regions. The military upturned this to their favour in order to have full control of the nation's resources – (particularly crude oil). Centralized system of decision making is driven by quest for political power, while political power is driven by corruption. This centralized system of decision making has eaten deep into our political culture as a nation. Even with the eventual apparent collapse of military rule, we have seen this centralized decision making culture in our democratic setting. Full executive powers and decision making in the hands of the state executive governors and president.

I have been involved in different advisory services and consultancy till date with the federal government in various respects.

Interviewee W

Certainly, at this point in your research, you should have collected quite a lot of information. However, I will try not to bore you with a lot of details that you may have heard. I will only dwell on a few aspects which may not have been properly touched by other people you have interviewed. So, kindly toll your questions towards that direction.

I joined the then Nigerian Electrical Power Authority (NEPA) in 1981. As you are aware, there has been a few changes since then. NEPA metamorphosed to the Power Holding Company of Nigeria (PHCN). The PHCN was meant to be a holding of many companies which was to breakup into different independent companies. However, the PHCN remained for a longer time than was initially projected due to inconsistency on the part of the government to ensure a smooth and speedy transition and deregulation of the electricity sector.

Nigeria experienced a null period from the mid 1980’s to the early 2000’s. During this period, the only power plant that was commission was the Shiroro hydro power plant. No improvement was done on the network infrastructure, neither was there any plan or budget for electrical network infrastructure improvement. This led to a further decay as the demand kept rising without any corresponding investment in electrical supply infrastructure.

With regards to policy, there used to be a very good relationship between the then NEPA, and the government and there were no issues in terms of alignment between public policy and energy infrastructure provisions. This was so because once anyone was recruited by the NEPA, they had to regularize their employment status with the Ministry of Establishments (which is an arm of the federal government). This meant that there had to be a good cordial working relationship for things to move on smoothly. The government, through the Ministry of Establishment, as well as NEPA had several joint projects, as such, policy makers involved in taking decisions on electricity infrastructures on the part of the government were also major stakeholders in the business of managing the entire electrical network. This situation however collapsed over the decades, just like many other sectors, and today, we all suffer the effect a system where policy makers (who are not competent on the subject matter) parade themselves as subject matter experts, and take decisions without consulting major stakeholders who have had a lot of experience in this sector.

Appendix 8 – EXAMPLE OF PEN/PAPER CODING OF INTERVIEW NOTES

expectation from the energy industry

With regards to energy demand evolution, the energy and electricity sector has failed, just like any other sector of the economy, primarily as a result of failure of national planning process. Nigeria, as a nation, have lost the planning culture as no serious national planning was done for a long time. The last national planning was done by the Yakubu Gowon administration (1966 – 1975). The successive national planning that was done prior to the last one done by the Yakubu Gowon led administration focused on different aspects of national life and planning for current and future provisions of various infrastructures such as electricity, water, transportation, industrialization, among others in order to cater for the current needs at that point, and also for the future needs which were influenced by increased demand caused by industrialization, urbanization, and growing population.

No national plan

Industrialization key to increased demand.

Electricity and railway transport provision were great contributors to industrialization which also influenced the rise in energy demand and consumption. Electricity generation in Nigeria started in the early 1900's. This provision led to the rise in the industrial and commercial activities which further influenced demand. Industrialization and energy demand continued to grow as the more businesses sprang up. Massive industrialization continued until the 1970's.

increased industrialization

increased energy demand

The Niger Dams Authority was set up to manage and develop the hydro-power potential for the country. It was through that that the Kanji and Shiroro dams were constructed (among other dams). The Electricity Commission of Nigeria (ECN) was also formed to manage all the diesel and coal fired power plants in the country. The National Electric Power Authority (NEPA) was a result of a merger of both the ECN and the Niger Dams Authority so as to have a single umbrella body responsible for the generation, management and planning of electrical power infrastructures in Nigeria. The period of the merger and the formation of NEPA coincided with the period when Nigeria saw the last serious national planning.

centralised decis

At this time, in the 1970's, there were many industries. Industrialization was at its peak in Nigeria. Electricity demand was growing geometrically, and there was need for fidelity to the implementation of the national planning agenda on electrical power in order to ensure that industries and the industrialization process is supported. Planning was done since the 1920's that foresaw the future growth of energy demand and consumption. Most of the national planning that was done in Nigeria was done during the colonial times. After the 1970's, Nigeria experienced a massive de-industrialization. The de-industrialization was caused not only by the impact of some decisions under the military rule, but also by insufficient supply of electricity to meet the industrial demand. As such, energy consumption declined more due to de-industrialization. Lack of electricity led to de-industrialization. What is currently projected as the estimated electricity demand is something very fictitious and does not reflect reality. The provision of more energy infrastructures will awake a new phase of demand. More people who were not able to use certain kinds of equipment due to non-provision of electrical power will start to use them, those who have relied on local generating sets for electricity generation for their businesses will start to weigh the options of connecting to the public utility, among others which will really impact on a new phase of increased demand.

Energy forecast

reduced energy

infrastructure provision

Color influence in nat plan

de-industrialization Nigeria

future version of energy industry

What we need is a diversified energy mix. We have ample primary energy resources that can be used for electricity generation which we are not currently exploring (some of them we have explored in the past

future version of the energy industry

energy mix

Appendix 9 – EXAMPLES OF RECURRING NOTIONS AND STATEMENTS DURING THE INTERVIEWS

Incompetence
Governance
Legislation
Future
History
Lack of vision
No sense of purpose
I wonder how the future will look like
Corruption
The rules are not clear
Policy inconsistencies
Policy summersault — policy inconsistency,
Avoiding expert advice
Infrastructure financing
Future energy — energy future visions
Energy policies — legislation
Infrastructure decay
Energy for industrialization - future of energy
Energy demand
Infrastructure supply
Dilapidating infrastructure
International aid
Aid policy - changing aid landscape
Foreign aid
United Nations
Millennium Development Goals — New Sustainable development Goals
Climate change — Paris Agreement
Environment
Sustainable energy
External influences
Funding bodies — foreign aid/donor agencies

APPENDIX 10: CODING FRAME FOR INTERVIEWS

Code	Description of code	Example extract from interview notes
Competencies	Practical knowledge of energy (including infrastructure, legislation and governance knowledge)	…the situation however collapsed over the decades, just like many other sectors. Today, every Nigerian suffers the effect of a system where policy makers (who are not competent on the subject matter) parade themselves as subject matter experts, and take decisions without consulting other stakeholders who have the requisite knowledge and experience.
Expectations	Past, current and future expectations of Nigerians (and external stakeholders – including investors) from the energy (electricity) industry	Nigerians expect to see an electricity sector that can help drive growth. A sector that can support small businesses and provide impetus for the establishment of new ones. Currently, it is very pathetic to see lots of business ideas die out because of the high cost of self-generation of electricity.
Legislation	Institutionalized and unwritten rules/procedures	There is no policy consistency. The rules are not clear.
Future visions	Future vision of the energy industry and the energy market (particularly electricity)	After a long period, there were some serious attempts made in 2005, with a clear roadmap in correcting the anomalies which led to the electrical power sector reforms. We need electricity to support industries
Recruiting experts	Recruiting new energy and public policy experts	The Olusegun Obasanjo's administration paid attention, after almost six (6) years of learning, on the need to recruit the right subject matter experts to run the affairs of the energy sector
Climate change	Referring to the need to adopt the use of energy sources with minimal environmental impact	There are lots of talks on renewables. We need to start to think about this while addressing our energy issues.
Development Goals	Referring to the United Nations Millennium Development Goals (and the new Sustainable Development Goals)	Energy access for all as a UN target makes it essential that we need to address our energy and electricity challenges. We cannot afford to take the back seat anymore, or continue the blame culture.
Changing aid landscape	Referring to the changing nature of foreign and international aid	A lot of international donors come with their own interests. We have to be very careful to ensure that those donors we are seeking to work with have the same interests as ourselves. If not, we may end up creating more problems.